LANDSAT 7 SYSTEM

DATA FORMAT CONTROL BOOK (DFCB)
VOLUME I - DATA ACQUISITION PLAN (DAP)

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Revision -

NASA/Goddard Space Flight Center
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Code 430
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SECTION 1

1. INTRODUCTION

1.1 *Identification*

This Data Acquisition Plan (DAP) is the first volume of a five volume set of documents which comprise the Data Format Control Book. It describes the Landsat 7 Project concept and plan for operating the Landsat 7 Spacecraft and the activities, communications links, and ancillary data required to acquire the Landsat 7 Wideband Data to satisfy the Landsat 7 mission requirements as levied by the Landsat 7 System Specification.

1.2 *Purpose*

The purpose of the DAP is to describe the Landsat 7 Project's plan for acquiring data from the Landsat 7 Spacecraft. It describes the operation of the Landsat 7 Flight Segment, Ground Segment and Communications links, and the activities and institutional support required to implement this plan. The DAP is an informational summary of all dataflows on the Landsat program and is not a requirements document. Therefore, it should not be used for design purposes.

1.3 *Scope*

This document describes the end-to-end data acquisition plan for the operational Landsat 7 System. In addition, it includes an appendix which describes the plan for data acquisition activities required to support the integration, test and launch activities which precede the beginning of on-orbit operations.

1.4 *Document Overview*

The DAP provides a description of the operational activities involved in the planning and acquisition of Wideband Data, and identifies the data types and their general paths through the Flight Segment, communication links, and Ground Segment in Section 3.1. It describes the four major data types: Telemetry, Command, Tracking and Wideband for the Landsat 7 spacecraft, and their flows through the Flight Segment, communication links, and Ground Segment. Section 3.2 provides a detailed description of the generation, contents, format, and transmission of each of the data types through the various components of the Flight Segment, communication links, and Ground Segment. Section 3.3 traces the flows of data from origin to destination, and describes the transmission media and data forms. Section 3.4 describes the data formats and content. Appendix A describes the requirements for support of systems integration, test, pre-launch operations, and launch.

1.5 *Related Volumes and Precedence*

The Data Format Control Book comprises 5 volumes, of which the DAP is the first. The other four volumes are Volume II (Command), Volume III (Telemetry), Volume IV (Wideband Data), and Volume V (Level OR data Format). These volumes provide detailed definitions of the content and formats of the respective data streams.

1.5.1 Landsat 7 Data Format Control Book, Volume II (Command)

This volume contains the definition of the command list and formats used for transmitting commands from the MOC through the communication links to the Landsat 7 spacecraft. This

volume takes precedence over all other documents concerning the Landsat 7 command data format definitions. This volume is "For Official Use Only".

1.5.2   Landsat 7 Data Format Control Book, Volume III (Telemetry)

The volume contains a description of the telemetry data stream generated by the Landsat 7 Command and Data Handling Subsystem, as well as a telemetry list and telemetry matrix assignment definition. The Standard Controls Processor (SCP) control of formats, and its contribution to telemetry, and definition of all telemetry formats is included. This volume takes precedence over all other documents concerning the Landsat 7 telemetry data format definitions. This volume is "For Official Use Only".

1.5.3   Landsat 7 Data Format Control Book Volume IV (Wideband Data)

This volume contains the definition for the Landsat 7 Enhanced Thematic Mapper Plus (ETM+) Wideband Data, and the formats used for transmitting the data through the communication links and the various Ground System elements. This volume takes precedence over all other documents concerning the Landsat 7 Wideband Data format definitions.

1.5.4   Landsat 7 Data Format Control Book Volume V (Level OR Distribution Product)

This document contains the definition for the format of the Level OR Landsat 7 Image Data. This volume takes precedence over all other documents concerning the Level OR Image Data Product format definition.

1.6   *Issue and Revisions*

The Data Acquisition Plan is issued for and applicable to the entire Landsat 7 system. Change page revisions will be issued as necessary by the Landsat 7 Project Configuration Control Board. A revision status of applicable volumes will be given immediately before the table of contents as part of the update for the Data Acquisition Plan. For submission of updates or changes, contact the Landsat 7 Project Office, Project Support Manager at Goddard Space Flight Center, Code 430, Greenbelt, MD, 20771.

2.   APPLICABLE DOCUMENTS

2.1   *Program Documents*

The following documents, of the exact issue shown, where listed, or the latest approved issue, where not listed, form a part of this document to the extent specified herein. In the event of a conflict between the documents referenced herein and this document, the contents of the referenced document shall be considered the superseding requirement. No attempt will be made to update this list with the latest revision letter.

23007555	On-Orbit Handbook/O&M Manual
PS23007563C	Space Segment Software Requirements Specification
23007627A	Landsat 7 Space Segment to Mission Operations Center ICD, August 1995
23007638C	Radio Frequency Interface Control Document Between the Landsat 7 and Space Network (SN), Ground Network (GN), and Landsat Ground Station (LGS)
23007640	Landsat 7 to International Ground Stations Interface Control Document
23007689A	Landsat 7 Space Segment Satellite Operations Concept and Timeline
23007702-IIC	Data Format Control Book (DFCB) Volume II - Commands, August 15, 1995. This document is For Official Use Only.
23007702-IIIC	Data Format Control Book (DFCB) Volume III - Telemetry, August 22, 1995. This document is For Official Use Only.
23007702-IVC 1996	Data Format Control Book (DFCB) Volume IV - Wideband Data, March 8,
430-11-06-007-0	Data Format Control Book (DFCB) Volume V - Landsat 7 Level OR Distribution Product
23021079	Interface Control Document Between Satellite Checkout Station (SCS) and TDRSS Users' RF Test Set (TURFTS), August 1995
430-11-01-003-0	Landsat 7 Detailed Mission Requirements, July 1995
530-ICD-NCCDS/MOC (Rev. 1)	Data Format Control Document Between the Network Control Center Data System and Payload Operation Control Centers, December 1994
553-FDD-95/003R0UD0 430-11-06-006-0	Landsat 7 / Flight Dynamics Facility Interface Control Document.
560-1ICD/0794	Interface Control Document Between the Landsat 7 Ground Station and the Landsat 7 Processing System.

L7-PM-235C   Landsat 7 Solid State Recorder Interface Control Document, September 1995

TBD   ICD for WOTIS and MOC

TBD   Mission Operations Plan

TBD   ICD for EDC DAAC and Landsat 7

TBD   ICD for LPS and IAS

2.2   *Non-Program Documents*

The following documents, of the exact issue shown (where listed), or the latest approved issue, form a part of this document to the extent specified herein. In the event of a conflict between the documents referenced herein and this document, the contents of the referenced document shall be considered the superseding requirement. No attempt will be made to update this list with the latest revision letter.

CCSDS 101.0-B-2   Recommendations for Telemetry Channel Coding, January 1987

CCSDS 701.0-B-1   Recommendations for Advanced Orbiting Systems, Networks and Data Links, October 1989

MIL-STD-1750A   Military Standard, Sixteen-Bit Computer Instruction Set architecture

SECTION 3

3. LANDSAT 7 SYSTEM DATA ACQUISITION DESCRIPTION

3.1 *Landsat 7 Project Operational Overview*

The Landsat 7 Data Acquisition Plan covers all aspects of the activities involved in collecting the Mission Wideband Data for the Landsat 7 Project. These activities include mission management, mission planning and operations (including all support functions), data acquisition, data processing, data archiving, quality assurance, and data distribution. The mission objective of

- Performing operations functions on behalf of NOAA, including data capture, data processing, assuring system performance and quality, and distributing data to all users.

3.1.2 Landsat 7 System Operational Overview

Mission planning and Satellite operations will be conducted in the Mission Operations Center (MOC), located at Goddard Space Flight Center, Building 32, Greenbelt, Maryland. Wideband Data will be downlinked to the Landsat Ground Station (LGS) and the International Ground Stations (IGS). Wideband Data will also be downlinked to selected Landsat Ground Network Stations and routed, via Common Carrier, to the LGS. Wideband Data from the LGS will be processed to a standard format known as "Zero-R" (OR) by the Landsat Processing System (LPS) located at EDC. It will be archived, along with supporting data necessary for higher level processing, in the EDC Distributed Active Archive Center (DAAC). The data will be labeled by "scene" corresponding to the Worldwide Reference System (WRS). The Landsat 7 System Requirements call for processing up to an average of 250 scenes per day. The Mission to Planet Earth program will use the Earth Observing System Data and Information System to further process up to 25 scenes per day to Level 1. The goal is to obtain complete coverage of the world's land masses with periodic updates of the data. With Landsat 7's orbit, repeat coverage for any given land mass can be obtained as often as every 16 days.

Routine on-orbit operations will normally be accomplished autonomously, by the execution of stored commands. These stored commands are transmitted to the spacecraft (S/C) daily. The S/C sends back housekeeping, health and safety data in both real-time and playback modes. When commanded, image data is collected; it may be transmitted directly to the IGSs, the LGS, or selected LGN stations, or stored onboard and played back later to the LGS or selected LGN stations. The Flight Dynamics Facility (FDF) will process S/C tracking data and perform orbit determination.

Operation of the Landsat 7 Spacecraft and collection of ETM+ data for the United States and International scientific communities entails a complex series of activities involving the generation and exchange of numerous messages and streams of data between the various elements of the Landsat 7 Project. This section of the DAP presents an overview of the activities, and identifies the elements and the data exchanges necessary to operate the S/C and effect the collection of the Wideband Data. These elements are as follows:

Flight Segment Handling Segment	Communication Links	Ground Data
Landsat 7 Satellite (MMO)	NASA Space Network (SN)	Mission Management Office
	Spitzbergen Ground Station (SGS)* Alaska Ground Station (AGS)*	Mission Operations Center (MOC) Network Control Center
(NCC)		
	Wallops Orbital Tracking Station (WOTS)* Landsat Ground Station (LGS)*	Wallops Orbital Tracking Information System
(WOTIS)*		
	International Ground Stations (IGS) NASA Communications Network	Flight Dynamics Facility (FDF) Landsat Processing System
(LPS)		
	(Nascom)	EDC Distributed Active Archive Center (EDC DAAC) Image Assessment System (IAS)

Those communication links marked with an asterisk are collectively referred to as the Landsat Ground Network (LGN). The LGN scheduling and operations are controlled by the WOTIS. The Nascom provides ground communication links among the Ground Stations and the Ground Data Handling Segment elements. Figure 3.1-1 depicts the various elements and the data exchanges pictorially. The data exchanges are discussed in detail in Section 3.2.

Data Acquisition activities are divided into Mission Planning and Mission Operations for discussion, although both take place concurrently on a daily basis. Mission Operations are further divided into Flight Operations and Data Processing Operations. Mission planning and Flight Operations are conducted in the Mission Operations Center (MOC), based on LCG policy decisions which flow to the MOC through the Mission Management Office (MMO). During the planning phase the MOC determines what data needs to be collected and how (real-time or store and playback), based on the Long Term Plan and Special

S Band
TT&C

S Band
TT&C

X-Band

X-Band
Science data 150 Mbps
(up to two)

**Mission Management
Office (MMO)**

Special Requests   Reports

**Landsat 7
Tracking Station Support**

o Wideband Data Receipt
o Narrowband Data Capture
o Narrowband Uplink
o Tracking data collection

NCC	WOTIS			
SN	LGS	SGS	AGS	WOTS

Commands
Telemetry
Orbital Information
Schedule, Coordination

**Landsat 7
Mission Operations Center
(MOC)**

o Planning and Scheduling
o Command and Control
o Health and Safety
o Trending
o Narrowband Telemetry
  Processing and Archive

**Flight Dynamics
Facility (FDF)**

Metadata and Browse

**Landsat 7
Processing System
(LPS)**

o Wideband Data Capture
o Data Processing (0R)
o Metadata and Browse
  Generation
o Data Assessment
oTemporary Storage

Level 0R Products

User Interaction

Level 0R Data, Cal Data
Metadata & Browse

o Data Archive
o Data Distribution
o User Interface & Services
o Algorithm Library
o Billing and Accounting

Requests from the MMO, request priority level, archive requirements, and S/C resources. The MOC makes use of planning products produced on the FDF workstations located in the MOC or obtained directly from the FDF. The MOC then issues communications link and tracking support requests to the Network Control Center (NCC) and the WOTIS. Based on the support scheduled, the MOC may have to revise its plan and try again, or develop work-arounds. The NCC will send support schedules to the NASA Networks, and the WOTIS will send support schedules to the LGN and the MOC. The MOC distributes antenna pointing angles for the tracking stations, from the Flight Dynamics Facility (FDF). In addition, the FDF recommends orbit adjust operations. The MOC will generate the appropriate command files for the planned operations, and transmit them to the spacecraft.

Most spacecraft operations will be conducted through the use of stored commands. The stored commands generated in the MOC are sent, via the LGN or SN, to the S/C where they are stored in the Standard Controls Processor (SCP) memory. The SCP will issue commands at the proper time to configure the spacecraft to collect the Telemetry and Wideband Data for immediate transmission to the ground or storage for later transmission. The MOC and the ground stations will conduct operations at the proper time to receive the telemetry, Wideband Data and tracking data, and to send the command loads, as described in the following paragraphs.

The following types of contacts between the S/C and the ground system are anticipated:

- Real-time Wideband data to an IGS;
- Real-time and/or Playback Wideband data to the LGS and selected LGN Stations;
- Command Load and Real-time and/or Playback Telemetry Data through the LGN;
- Tracking through SN and the LGN; and,
- Emergency Command load and Telemetry Data acquisition through SN or LGN.

During the operations the following data flows will occur:

- Text, Telemetry, Command, Tracking data, and support data files will be exchanged among ground elements;
- Real-time and Playback Wideband data will be transmitted from the S/C to the ground;
- Real-time and Playback Telemetry Data will be transmitted from the S/C to the ground;
- Command files will be transmitted from the ground to the S/C; and,
- Wideband Data files will be exchanged among the ground elements.

Ground Data Processing Operations will occur in the Landsat Ground System, and will involve exchanges among the LGS, IGSs, MOC, FDF, LPS, EDC DAAC, and IAS. The S/C will transmit Wideband Data directly to selected LGN Stations, and IGSs. The Wideband Data will be captured in real-time by the LGS. The other LGN Stations will send their Wideband Data to the LGS via Common Carrier. This Wideband Data will be sent by the LGS to the LPS later. The LPS will process the data to the Level OR form and generate Image Data, Metadata and Browse Data files which will be sent to the EDC DAAC. The IGSs will send Browse Data and Metadata files, for their image data, to the EDC DAAC. Definitive ephemeris from the FDF will be sent to the IAS for use in producing data products for analysis and assessment.

3.2   *System Elements and Interfaces*

This section describes the functions performed by the system elements listed in Section 3.1, and identifies the products and interfaces of the element. The interfaces are summarized in Table 3.2-1. This Table identifies the types of interfaces between the different elements, and identifies the types of products. The types of interfaces are voice, paper, electronic and radio

frequency (RF) transmissions. Voice interfaces are for requests for information, coordination and problem resolution. Paper interfaces convey printed

From \ To	Landsat-7	IGS	LGS	TDRSS (WSC)	AGS	SGS	WOTS	NCC	FDF	MOC	WOTIS	IAS	MMO	LPS
Landsat-7		5	5,7,8	7,8	5,7,8	5,7,8	7,8							
IGS										3			1,2,3	
LGS	6,8								4	1,3,4	1,3,4			3,4,5
TDRSS (WSC)	6,8							1,3,4	4	1,3,4				
AGS	6,8		5						4	1,3,4	1,3,4			
SGS	6,8		5						4	1,3,4	1,3,4			
WOTS	6,8								4	1,3,4	1,3,4			
NCC				1,3						1,3,4				
FDF										1,2,3,4				
MOC		3,4	1,3,4	1,3,4	1,3,4	1,3,4	1,3,4	1,3,4	1,3,4		1,3,4	1,3,4	1,2	1
WOTIS			1,3,4		1,3,4	1,3,4	1,3,4			1,3,4				
IAS										1,3,4			1,2	3,4
MMO		1,2								1,2		1,2		1,2
LPS			1,3,4							1,2		3	1,2	
DAAC										4		3,4	1,2	3
Users													1,2	

Legend:
1   Voice   5   X-Band Science data
2   Paper text   6   S-Band Command
3   Electronic text messag   7   S-Band Telemetry
4   Electronic data file   8   S-Band Tracking

Table 3.2-1. Interface Chart

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information such as requests for information, printed schedules, and pass summary reports. The same type of information can be sent as text files across electronic interfaces. In addition, data files or packets such as telemetry data, command files, data bases, tracking and orbit information, and Wideband Data files can be transmitted across electronic network interfaces. The RF interfaces carry command, telemetry, tracking and instrument data. These interfaces, and the products flowing across each one, are described in the following sections.

3.2.1 Spacecraft Operation

The Spacecraft (S/C) consists of the bus and payload. The S/C is designed for a 705 km, sun synchronous, earth mapping orbit with a sixteen day repeat cycle. The S/C will collect terrestrial data of interest, using the Enhanced Thematic Mapper Plus (ETM+) payload, in specific visible and near infrared (VNIR) bands, short wavelength infrared (SWIR) bands, a thermal long wavelength infrared (LWIR) band and a panchromatic band, and transmit it via direct X-band downlinks to selected LGN stations and IGSs. The S/C provides three steerable antennas and four transmitters, operating at three different frequencies, for X-band downlink. The S/C utilizes a store and forward capability to support US acquisition of non-Continental United States data.

S-band links are used to transmit command and telemetry data between the S/C and the ground. There are two S-band antennas located on opposite sides of the satellite (nadir and zenith pointing). Each antenna provides essentially hemispherical coverage. S-band transmitters are configured to be switched to one S-band antenna or the other. In addition, both transmitters can be operated simultaneously for spherical coverage. A summary of the RF communication links to the S/C is shown in Figure 3.2-1.

The Landsat Ground Network consists of multiple communication networks which have the capability to provide S-band and/or X-band communication support to the Landsat-7 mission. The LGN includes the Alaska Ground Station, the Spitzbergen Ground Station, the Wallops Orbital Tracking Station, the LGS, and the Wallops Orbital Tracking Information System.

NASA's Space Network, consisting of the Tracking and Data Relay Satellites (TDRS) and the ground station at the White Sands Complex (WSC), collects Landsat-7 S/C tracking data for FDF processing. The SN is also used for real-time command and telemetry monitoring during on-orbit operations on a scheduled basis and possible emergency operations on a call up basis. The S/C to SN interface is defined in the RF ICD Between Landsat 7 and Space Network, 23007638

3.2.1.1 Downlink Data Generation

The S/C utilizes an S-band downlink for the transmission of Telemetry Data, and an X-band downlink for the transmission of Wideband Data from the ETM+ payload. Telemetry Data is generated and recorded at all times. Wideband Data is only generated on command.

3.2.1.1.1 Telemetry Data Generation

Telemetry data contains all of the information required to monitor and assess the health of the satellite, verify day-to-day operations, and assist in anomaly resolution. Telemetry data is always recorded on the SSR. It can be downlinked in real time as it is being recorded, or played back on a later pass from the recorder. The telemetry data stream generation is shown in the block diagram in Figure 3.2-2.

**LANDSAT 7
Spacecraft**

S-band

**C&DH
Transponder**

Command:125 or 1000 bps & ranging	NRZ-M/PN/UQPSK	2106.4 MHz	
Realtime TLM:1216 or 4864 bps	NRZ-M/SQPN	2287.5 MHz	
Command:125 bps & ranging	NRZ-M/PN/UQPSK	2106.4 MHz	
Realtime TLM:1216 bps	NRZ-M/SQPN	2287.5 MHz	

Omni (zenith)

S
S
A

S
M
A

TDRS
S-band

Command: 2000 bps & Coherent Doppler	NRZ-M/PSK/PM	2106.4 MHz	
PB TLM: 256 kbps RT TLM: 1216 or 4864 bps Coherent Doppler	Biphase-S/PM Biphase-S/PSK/PM	2287.5 MHz	

LGS
S-band

Omni (nadir)

Command: 2000 bps	NRZ-M/PSK/PM	2106.4 MHz	
PB TLM: 256 kbps RT TLM: 1216 or 4864 bps	Biphase-S/PM Biphase-S/PSK/PM	2287.5 MHz	

**AGS
SGS
WOTS**
S-band

X-band

**Direct
Transmitter**

Science data 150 Mbps (up to 2)	NRZ-L/AQPSK	8082.5 MHz 8212.5 MHz 8342.5 MHz

**LGS
SGS
AGS**
X-band

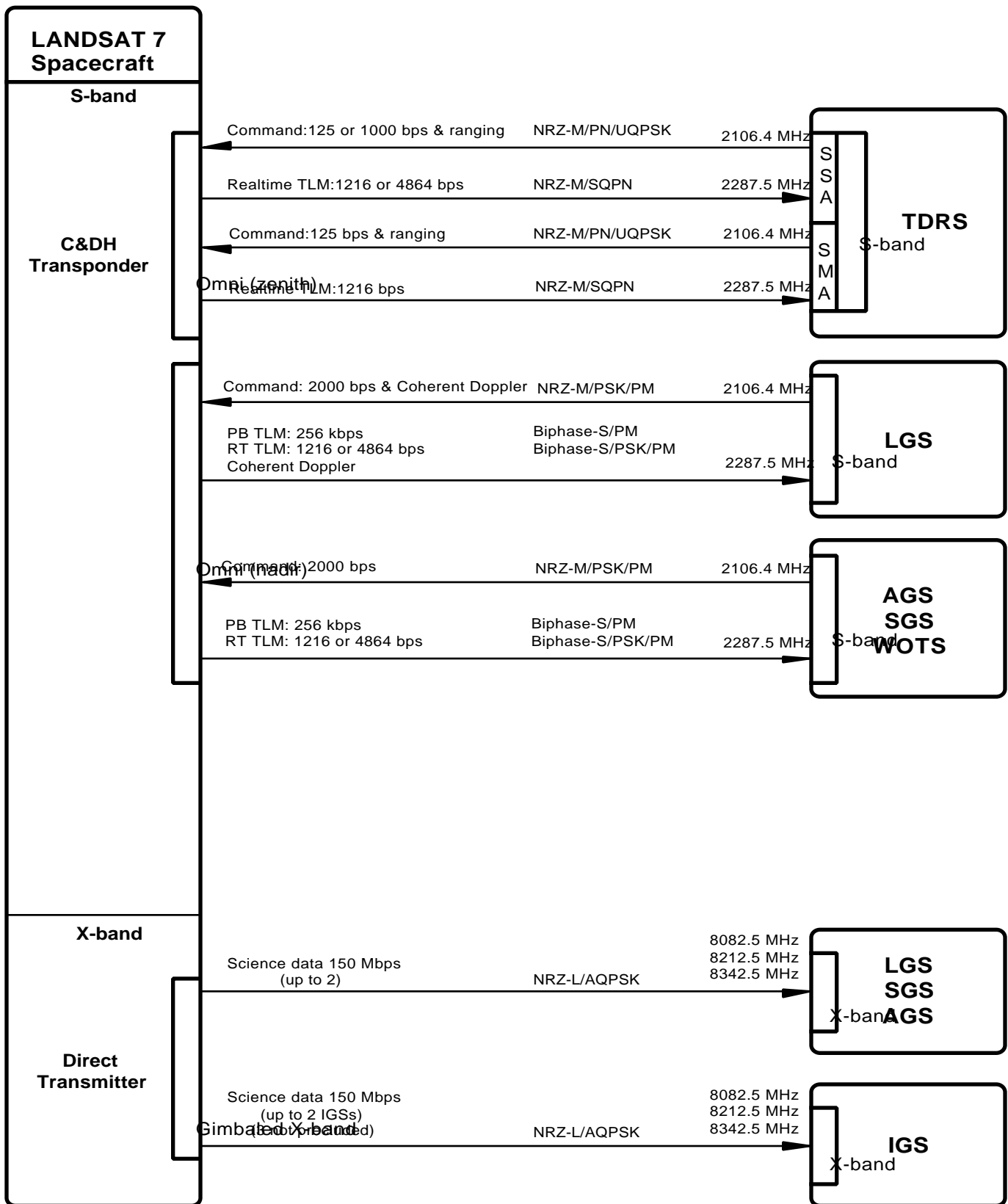|		
Science data 150 Mbps (up to 2 IGSs)	NRZ-L/AQPSK	8082.5 MHz 8212.5 MHz 8342.5 MHz

Gimbaled X-band

IGS
X-band

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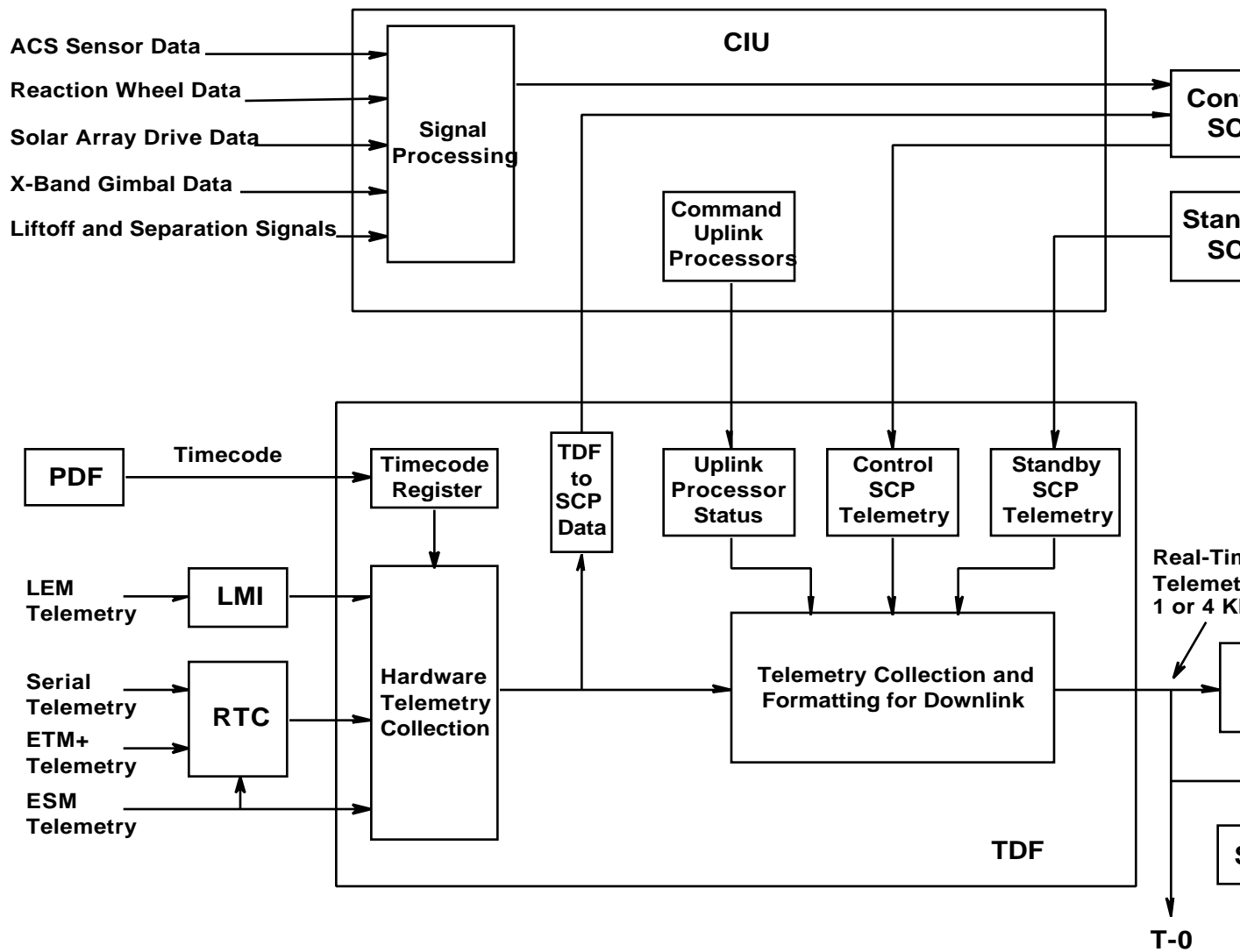Figure 3.2-1. Landsat 7 Spacecraft Interfaces and Dataflows

Figure 3.2-2. Telemetry Data Generation

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3.2.1.1.1.1 Link Description

The downlink of telemetry from the Landsat-7 is an S-band link through the Landsat Ground Network or the SN. The S-band downlink frequency is 2287.5 MHz. When using the TDRSS S-band Single Access service, real time telemetry is transmitted at 1.216 kbps or 4.864 kbps. When using the TDRSS S-band Multiple Access service, real time telemetry is transmitted at 1.216 kbps only. When using LGN ground stations, the telemetry is transmitted at 1.216 kbps or 4.864 kbps for real time and 256.0 kbps for playback.

3.2.1.1.1.2 Implementation

During operations, telemetry is collected and formatted by the Command and Data Handling (C&DH) subsystem. The C&DH collects telemetry from all the satellite subsystems, including the SCP and the ETM+ payload, formats a subset of it into minor and major frames, and encodes the frames into a CCSDS compliant downlink stream. The datastream is recorded on a Solid State Recorder (SSR). It may also be provided to the Communications (COMM) subsystem for downlinking in real-time simultaneously with recording. The recorded telemetry stream is played back and downlinked at a later time. This playback data is identified as such by a bit in the CCSDS framework.

The C&DH subsystem provides the means for collecting and formatting satellite telemetry. The C&DH subsystem equipment involved with telemetry processing includes two Standard Controls Processors (SCPs), one Controls Interface Unit (CIU), one Remote Telemetry and Command Unit (RTC), one Lower Equipment Module Interface (LMI), one Telemetry Data Formatter (TDF), and one SSR module.

The TDF continually collects, formats, and outputs a telemetry data stream. The TDF formats a subset of the collected telemetry into minor and major frames, encodes the frames into CCSDS compliant downlink protocol and sends the encoded data to the SSRs for recording. The encoded data may also be sent to the S-band Transponder for transmission to the ground. The TDF also sends 10 words, which are a subset of the telemetry sent to the ground, to the SCPs to support FSW processing. The SCP is the platform for Flight Software (FSW) storage and execution

Telemetry can be characterized as hardware telemetry or FSW telemetry. Hardware telemetry consists of analog, bilevel, and serial digital data. Hardware telemetry is collected in eight bit bytes under the control of the TDF. The LMI collects analog and discrete data from the Signal Conditioning Unit-Lower Equipment Module (SCL), Electrical Power Subsystem (EPS), and Lower Equipment Module (LEM) heaters and forwards this telemetry to the TDF. Similarly, the RTC collects analog and discrete data from the ETM+ payload, SSR, Baseband Switching Unit (BSU) SSR, and S-band Transponder, and forwards this telemetry to the TDF.

The control SCP generates the FSW telemetry and sends it to the TDF via the CIU. The standby SCP also sends telemetry to the TDF, via the CIU, concerning its status. FSW telemetry consists of hardware status data received by the FSW via the CIU, and FSW generated data, including S/C position, attitude, rates, memory dump and command verification data. Telemetry is time stamped using the time code received from the Payload Data Formatter (PDF).

The COMM subsystem contains two S-band transponders that receive a CCSDS encoded telemetry data stream from the TDF and SSR and modulate the data for transmission to a TDRS or to a LGN ground station. The signal is transmitted from two antennas located on opposite sides of the S/C (nadir and zenith pointing). The zenith antenna is used for TDRS communications; the nadir antenna is used for LGN communications. Each antenna provides essentially hemispherical coverage.

3.2.1.1.2   Wideband Data Generation

The wideband data consists of ETM+ instrument data with embedded Payload Correction Data (PCD) and Status data. The PCD is the ancillary spacecraft data needed to properly process the ETM+ image data, and is provided to the ETM+ by the satellite Command and Data Handling (C&DH) subsystem. The wideband data stream generation is shown in the block diagram in Figure 3.2-3.

3.2.1.1.2.1   *Link Description*

The downlink of wideband ETM+ data is an X-band link to selected sites of the LGN or to International Ground Stations. The X-band downlink frequencies are 8082.5 MHz, 8212.5 MHz, and 8342.5 MHz. Modulation is NRZ-L/AQPSK, providing 150 Mbps of data consisting of two downlink data streams (or channels) of 74.914 Mbps each on a carrier.

3.2.1.1.2.2   *Implementation*

The ETM+ contains sensors that detect earth scene radiation in visible and near infrared (VNIR) bands, short wavelength infrared (SWIR) bands, and a thermal long wavelength infrared (LWIR) band. The ETM+ contains two multiplexer subsystems, each connected to a Baseband Switching Unit (BSU), and each of which are capable of concurrently sampling and digitizing video and analog signals from the sensors to produce eight bit words of scene data. Each multiplexer provides a high rate, 74.914 Mbps, digital output serial data stream for each of two possible scene data formats so that a given multiplexer subsystem provides both scene data formats simultaneously to the BSU.

Each high rate digital output serial data stream is encoded into a CCSDS recommended framework for space channel transmission. PCD and status data, which includes attitude and ephemeris data, gyro data, selected ETM+ telemetry, band gains, time, and Angular Displacement Assembly (ADA) data, is included in each CCSDS transfer frame.

The PCD is provided to the ETM+ by the Payload Data Formatter (PDF) of the C&DH subsystem. The PDF accepts attitude, ephemeris, gyro drift rate, ETM+ telemetry, and spacecraft attitude control mode data from the CIU, angular displacement sensor and temperature transducer data from the Angular Displacement Assembly (ADA), and gyro pulses from the Inertial Measurement Unit (IMU) of the Attitude Control System (ACS). The PDF also contains a presettable time code generator from which time code information is made available to the ETM+, TDF, and CIU.

The pair of CCSDS encoded, serial data streams from each ETM+ multiplexer is received by a BSU. There are two BSUs, one for each pair of outputs from the ETM+. The BSUs also provide the 74.914 MHz timing signals to each ETM+ multiplexer. The BSU forwards the data streams either to the COMM system for real-time downlink or to the SSR to be recorded. The two data streams from each ETM+ multiplexer remain a matched pair throughout record, playback, and transmission operations. The SSR playback is read out of memory and mapped into one or two groups of two 74.914 Mbps bit streams with a total aggregate rate of approximately 150 or 300 Mbps. The playback data is transmitted to the COMM subsystem via the BSU.

The COMM subsystem provides three steerable antennas and four transmitters, operating at one of three different frequencies, for X-band downlink. The COMM provides for the transmission of a 150 Mbps data stream to two unique ground sites simultaneously or two unique 150 data streams to the same ground site., simultaneously. The COMM does not preclude the capability for up to three 150 Mbps data streams to the ground simultaneously.

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3.2.1.2   *Uplink Data Processing*

The uplink is used for commanding operations. All of the commands required to configure and operate the satellite for the duration of the Landsat-7 mission are transmitted through the uplink. The processing of commands is shown in the block diagram in Figure 3.2-4.
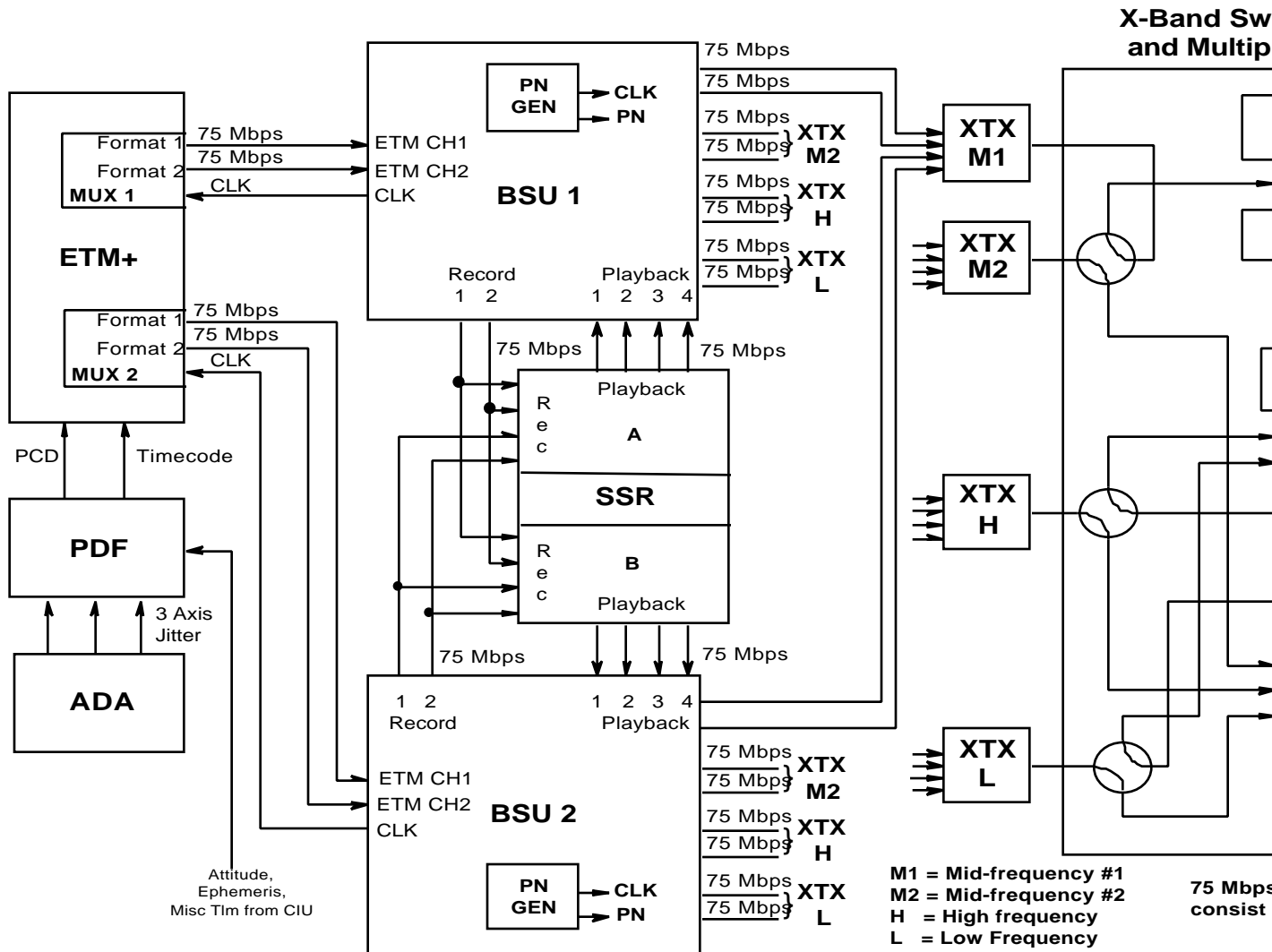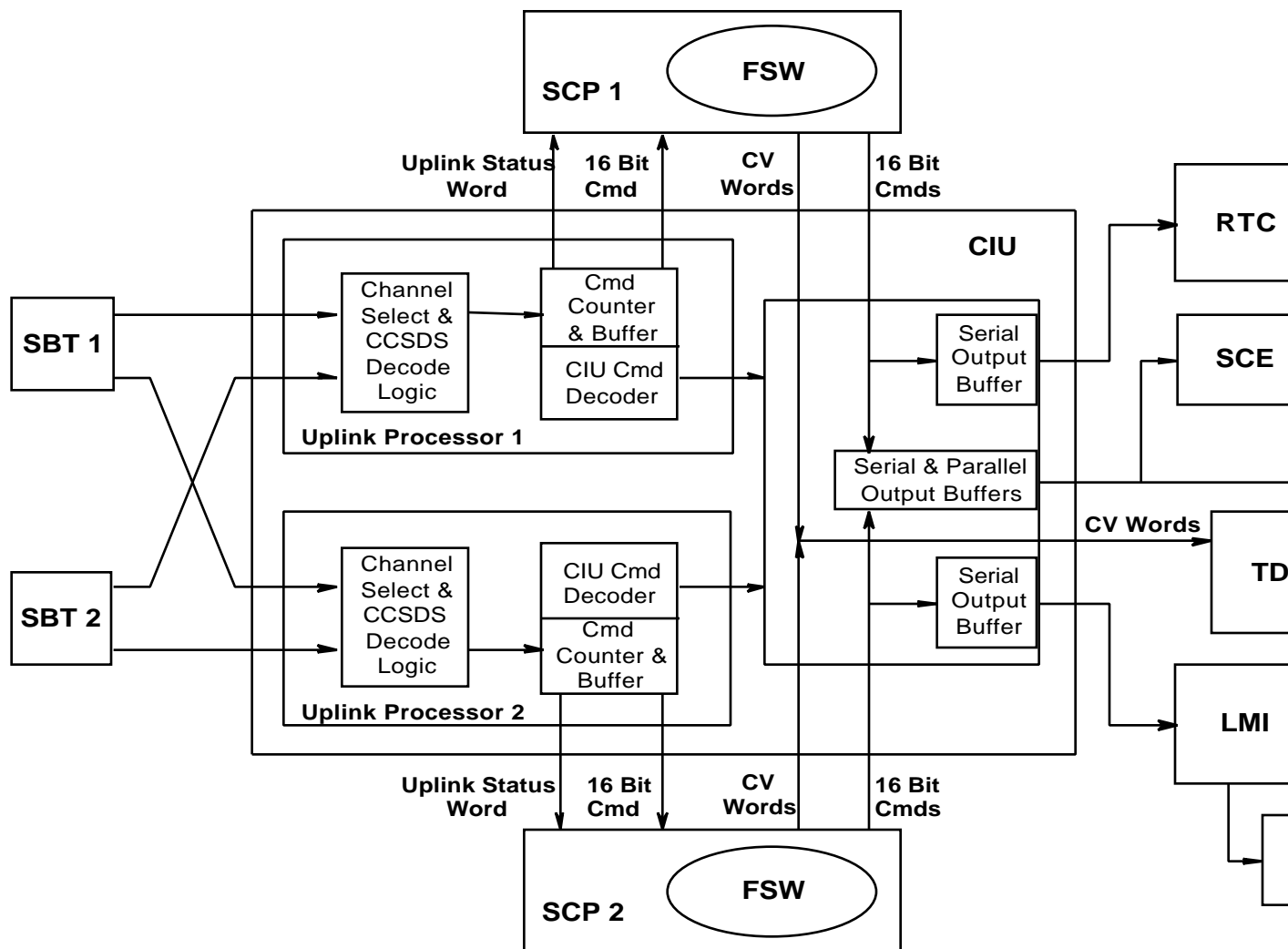
Figure 3.2-3. Wideband Data Generation

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Figure 3.2-4. Command Data Processing

3.2.1.2.1   Link Description

The uplink to the Landsat 7 satellite is an S-band link through the Landsat Ground Network (LGN) or the SN. The S-band frequency is 2106.4 MHz when using the uplink/forward link services. When using the LGN ground stations, the command data is transmitted at 2.0 kbps. When using the TDRSS S-Band Single Access (SSA) service, the command data is transmitted at 125 bps or 1.0 kbps; when using the S Band Multiple Access (SMA) service the command data is transmitted at 125 bps.

3.2.1.2.2   Implementation

All ground generated commands are received on the satellite by the Communication (COMM) subsystem, where the command signal is demodulated from the uplink carrier, and then sent to the Command and Data Handling (C&DH) subsystem for processing. The C&DH and the COMM are compatible with any of the command sources.

The COMM receivers will process a command source once sufficient carrier strength from a TDRS or a ground station is received. There are two S-band antennas, located on opposite sides of the satellite (nadir and zenith pointing). Each antenna provides essentially hemispherical coverage.

Also included in the COMM are two S-band transponders. Each transponder simultaneously looks for TDRSS suppressed carrier signals, and LGN residual carrier signals, and automatically reconfigures its circuits to process whichever signal is detected. The detected signal is demodulated from the uplink carrier and bit synchronized. The resulting digital command signals are delivered to the C&DH for further processing.

The C&DH includes the Controls Interface Unit (CIU) which contains two Uplink Processors (U/Ps), each being dedicated to one of the two Standard Controls Processors (SCP). The SCP is the platform for Flight Software (FSW) storage and execution. It contains the elements necessary to execute the mandatory instruction set specified by MIL-STD-1750A (Notice 1).

The U/Ps perform the CCSDS decode function. The U/P converts the data stream from NRZ-M to NRZ-L, synchronizes to the CCSDS command link transfer unit (CLTU), performs error detection using the BCH code, and unpacks the 32-bit spacecraft commands from the CCSDS telecommand structure.

Each 32-bit spacecraft command is composed of a 14-bit Spacecraft Command Counter (SCC), a 2-bit CPU Interrupt Code (CIC), and a 16-bit command. The U/P validates the command by verifying the SCC. A majority of all commands are processed and executed by one of the two SCPs. The exception is commands decoded by the CIU hardware. The U/Ps use the CIC to discriminate between SCP commands, SCP data words, and CIU hardware decoded commands. The CIU can executes the CIU hardware decoded commands internally, without help from the SCP. After execution, the hardware decoded command is passed to the SCP for inclusion in the command verification word in telemetry.

For SCP commands and SCP data words, the U/P interrupts the target SCP and provides the 16-bit command, or data word, along with a 16-bit uplink status word. The uplink status word contains associated modifiers, such as whether it is a command or data word, and status, such as an error flag. Commands are categorized based on when the commands are intended for execution. The three categories of software commands are real time commands, stored commands, and relative time command sequences (RTCSs).

In response to SCP commands, the FSW may send commands to satellite subsystems or perform a flight software operation. SCP commands that are destined for satellite subsystems are sent to the CIU for distribution to the targeted subsystems.

Command receipt verification is performed at two levels. For Landsat 7, a CLTU consists of a synchronization pattern, 2 to 36 telecommand code block, and a tail sequence. A telecommand code block is composed of seven-byte code blocks with a one-byte BCH error code. If an error is detected in any telecommand code block, the entire CLTU is rejected and the SCC is not incremented. Commands embedded inside subsequent CLTUs may pass the error detection, however, they will fail verification because their SCC will contain an incorrect value.

In addition, the FSW checks the syntax of SCP commands and rejects invalid commands. The FSW generates Command Verification (CV) words that provide a record of SCP command processing activities. The CV words are passed to the Telemetry Data Formatter (TDF) for inclusion in telemetry.

3.2.2 Communications Links

The Landsat 7 S/C communicates with the ground elements via a combination of RF and ground communication link networks. The function of the communication links is to convey commands from the MOC to the S/C, to convey Telemetry data from the S/C to the MOC, to convey Wideband Data from the S/C to the LGN and IGS respectively, and to provide communication among the ground elements. On the ground the data is routed to and from the various ground elements via Nascom, Local Area Networks, Ethernets, or Common Carrier.

3.2.2.1   *NASA Space Network*

The NASA Space Network consists of the TDRSS satellites and the White Sands Ground Terminal (WSGT). The function of the TDRSS is to acquire tracking data for the Landsat 7 Satellite, and to provide a backup link for commands and telemetry data. The S/C interfaces with the TDRSS at S-Band as defined in the RF ICD Between Landsat 7 and Space Network, Ground Network, and Landsat 7 Ground Station, 23007638. The SN interfaces and data flows are shown in Figure 3.2-5.

TDRSS will transmit the range channel PN code to the S/C. If it has been commanded into the proper configuration, the S-Band transponder on the S/C will perform a coherent regeneration of the PN code on a carrier with a frequency of 240/221 of the received carrier, and transmit it back to the TDRSS. The range data will be extracted at the WSGT and sent to the FDF via the MOC. The TDRSS will also use the Doppler shift information to generate range rate data and, during non-coherent transponder operations, to calibrate the S/C transmitter oscillator's frequency. This data will also be sent to the FDF. The TDRSS to MOC interface is defined in the Data Format Control Document Between the Network Control Center Data System and Payload Operation Control Centers, 530-ICD-NCCDS/MOC, and the Landsat 7 Detailed Mission Requirements Document.

TDRSS will also be used as an alternate station to send commands to the S/C and send telemetry from the S/C to the MOC. TDRSS can support command rates of 125 bps via the S-band Multiple Access Forward service, and 125 bps or 1.0 Kbps via the S-band Single Access Forward service. TDRSS can support telemetry data rates of 1.216 Kbps via the S-band Multiple Access Return service, and 1.216 Kbps or 4.864 Kbps via the S-band Single Access Return service.

The Network Control Center (NCC) will coordinate TDRSS operations and interface with the MOC for scheduling, real-time coordination, and problem investigation. The Interface between the

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NCC and the MOC is defined in Data Format Control Document Between the Network Control Center Data System and Payload Operation Control Centers, 530-ICD-NCCDS/MOC.
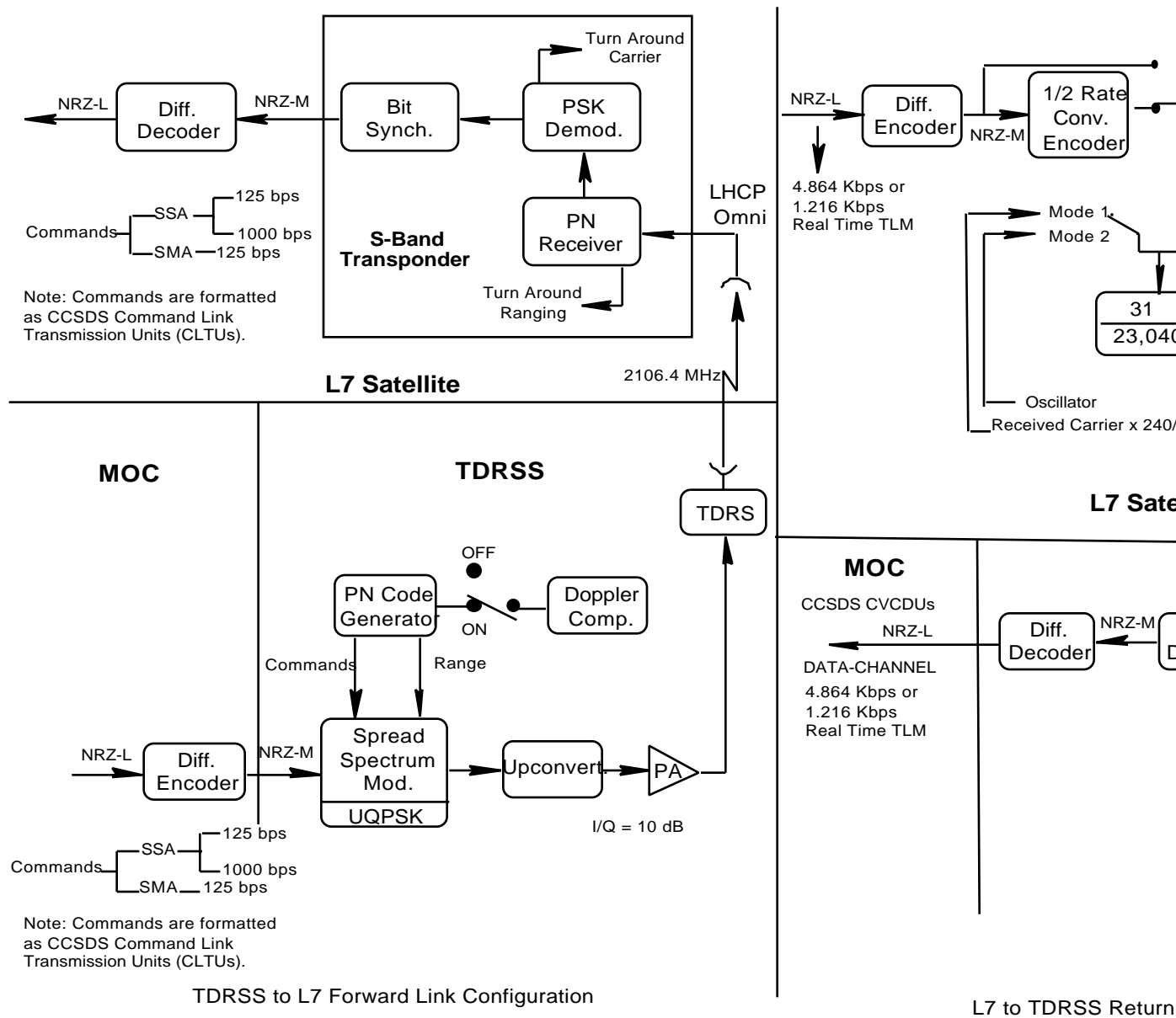
Figure 3.2-5. NASA Space Network Interfaces and Dataflows

3.2.2.2 *Spitzbergen Ground Station*

The Spitzbergen Ground Station (SGS) will provide S-band and/or X-band communications support to the Landsat 7 mission. The SGS shall be capable of communicating with the S/C as defined in RF ICD Between Landsat 7 and Space Network, Ground Network, and Landsat 7 Ground Station, 23007638C (TBR). The SGS interfaces and data flows are shown in Figure 3.2-6.

The WOTIS will be the point of contact for the MOC in scheduling SGS resources. The interface between the WOTIS and the MOC is defined in TBD ICD.

3.2.2.3 *Alaska Ground Station*

The Alaska Ground Station (AGS) will provide S-band and/or X-band communications support to the Landsat 7 mission. The AGS shall be capable of communicating with the S/C as defined in RF ICD Between Landsat 7 and Space Network, Ground Network, and Landsat 7 Ground Station, 23007638 (TBR). The AGS interfaces and data flows are shown in Figure 3.2-7.

The WOTIS will be the point of contact for the MOC in scheduling AGS resources. The interface between the WOTIS and the MOC is defined in TBD ICD.

3.2.2.4 *Wallops Orbital Tracking Station*

The Wallops Orbital Tracking Station will provide S-band communications support to the Landsat 7 mission. The WOTS shall be capable of communicating with the S/C as defined in RF ICD Between Landsat 7 and Space Network, Ground Network, and Landsat 7 Ground Station, 23007638 (TBR). The WOTS interfaces and data flows are shown in Figure 3.2-8.

The WOTIS will be the point of contact for the MOC in scheduling WOTS resources. The interface between the WOTIS and the MOC is defined in TBD ICD.

3.2.2.5 *Landsat 7 Ground Station*

The Landsat 7 Ground Station (LGS) will provide S-band and X-band communication support and be located at the EDC in Sioux Falls, SD. It will receive wideband and narrowband data downlinked from the Landsat satellite. It will forward ETM+ data to the LPS which also will be located at the EDC, and narrowband data to the MOC at GSFC. The LGS will also receive Wideband Data via common carrier, from selected LGN stations, for playback into the LPS. The LGS interfaces and data flows are shown in Figure 3.2-9. The S/C shall be capable of communicating with the LGS as defined in RF ICD Between Landsat 7 and Space Network, Ground Network, and Landsat 7 Ground Station, 23007638. The interface between the LGS and the LPS is defined in the ICD Between the Landsat 7 Ground Station and the Landsat 7 Processing System, 560-1ICD/0794.

The LGS will provide the capability to command the satellite and uplink spacecraft computer loads to the satellite. It will also support spacecraft clock drift determination and the collection of tracking data for orbit determination.

The MOC will send schedule messages to the LGS via the WOTIS. The MOC will also receive equipment reports and contact reports from the LGS via the WOTIS. The interface between the LGS and the MOC is defined in the Landsat 7 Ground Station to MOC Interface Control Document, TBD.

TBS

Figure 3.2-6. SGS Interfaces and Dataflows

TBS

Figure 3.2-7. AGS Interfaces and Dataflows

TBS

Figure 3.2-8. WOTS Interfaces and Dataflows

TBS

Figure 3.2-9. Landsat Ground Station Interfaces and Dataflows

3.2.2.6   *International Ground Stations*

The Landsat 7 Project will support a number of International Ground Stations. The function of the IGSs is to receive Wideband data for their local vicinity in real-time for their own use, and to provide Metadata and Browse Data to the EDC DAAC in non-real-time. The S/C shall be capable of communication with the International Ground Stations in accordance with the Landsat 7 to International Ground Stations ICD, 23007640. The IGS interfaces and data flows are shown in Figure 3.2-10.

The Landsat 7 S/C will transmit Wideband data directly to the IGSs in real-time via the X-band Direct Downlink as scheduled. The S/C has three steerable X-band antennas, and can transmit to up to three stations simultaneously.

The IGSs will receive schedule messages from the MOC, including orbital parameters. The Interface between the IGS and the MOC is defined in the Landsat 7 to International Ground Stations Interface Control Document, 23007640.

The IGSs will supply Metadata and Browse Data to the EDC DAAC. However, while customers can view Metadata and Browse Data from the EDC DAAC, they will have to order Wideband Data from the IGS. The IGS to EDC DAAC interface is defined in the Landsat 7 to International Ground Stations Interface Control Document, 23007640.
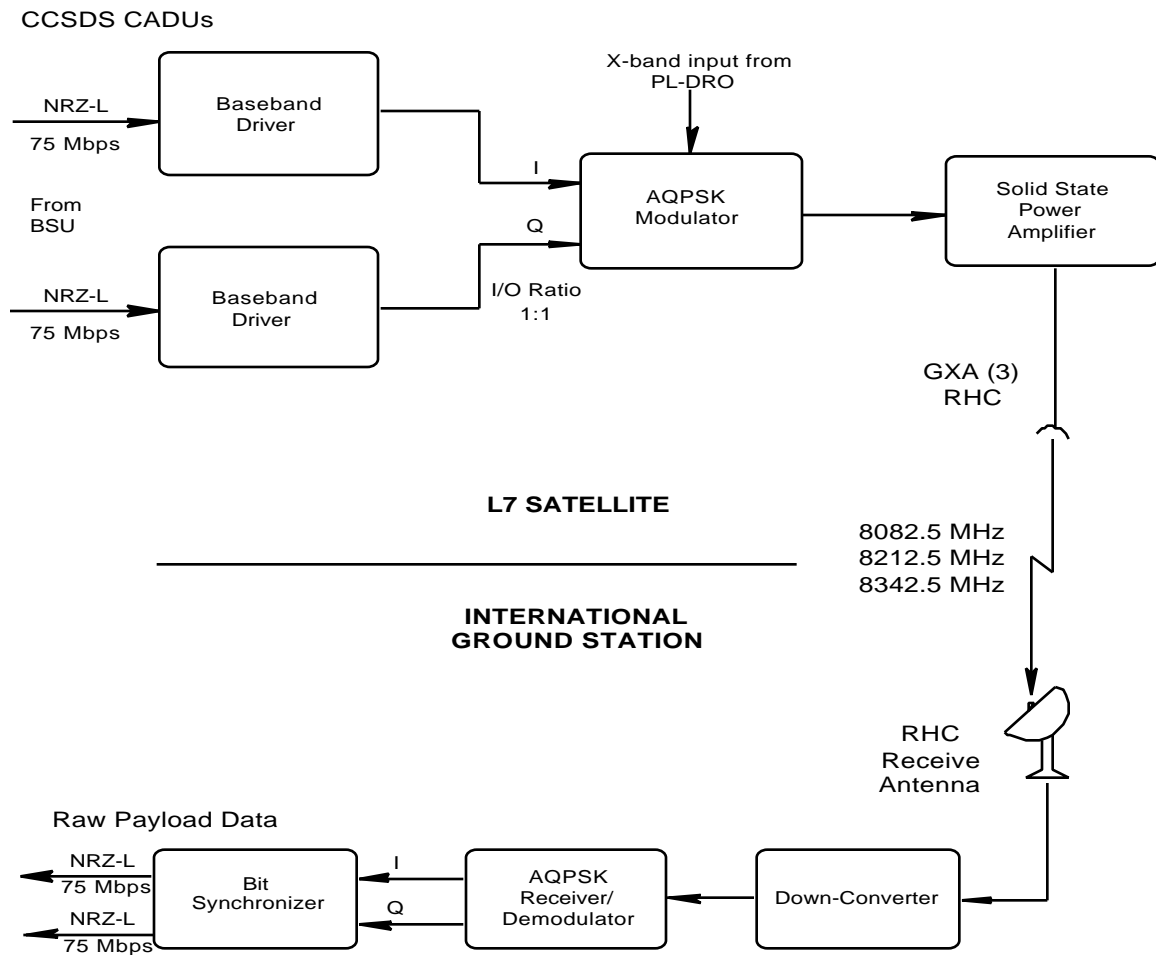
Figure 3.2-10. International Ground Station Interfaces and Dataflows

3.2.3 Ground Systems Operations

The Landsat 7 Ground System functions include mission planning, operations planning, S/C operations, data acquisition, data processing, data archiving, and distribution, and data assessment. The Ground System includes the following elements:

> Mission Management Office
> Mission Operations Center
> Network Control Center
> Wallops Orbital Tracking Information System
> Flight Dynamics Facility
> Landsat Processing System
> EDC Distributed Active Archive Center
> Image Assessment System

The first five elements listed are active in mission planning, spacecraft operations and data acquisition activities, while the last three are active in data processing, distribution and archiving activities. Their functions and interfaces are described in the following sections.

3.2.3.1 *Mission Management Office*

The function of the Mission Management Office (MMO) is to interpret project policy into operations guidelines, monitor project operations, and interface with the user community. It provides direction and guidance to the operational elements of the Landsat Project. It reports project status, revenues, and problems to the Landsat Coordinating Group (LCG). The MMO interfaces and data flows are shown in Figure 3.2-11. The interfaces and responsibilities of the MMO are defined in Section 4 of the Mission Operations Plan, TBD.

The MMO has an external interface with the user community. It receives and processes special requests for data acquisition. It handles non-routine contacts with the IGSs.

The MMO establishes rules and procedures, sets data acquisition priorities, and provides direction and guidance to the MOC.   It sends special processing requests to the MOC. The MMO to MOC interface is defined in the Mission Operations Plan.

The MMO provides direction and guidance to the LGS and LPS, and receives status and problem reports from the LGS and LPS. The MMO to LGS interface is defined in the Mission Operations Plan. The interface between the MMO and the LPS is defined in the Mission Operations Plan.

The MMO establishes Landsat 7 product costs for the EDC DAAC and coordinates problem investigation activities. The MMO receives statistics and reports, product sales data, and system management reports from the EDC DAAC. The MMO to EDC DAAC interface is defined in the Mission Operations Plan.

The MMO provides direction and guidance to the IAS and receives image assessment, status reports and data problem resolution reports from the IAS. The MMO to IAS interface is defined in the Mission Operations Plan.
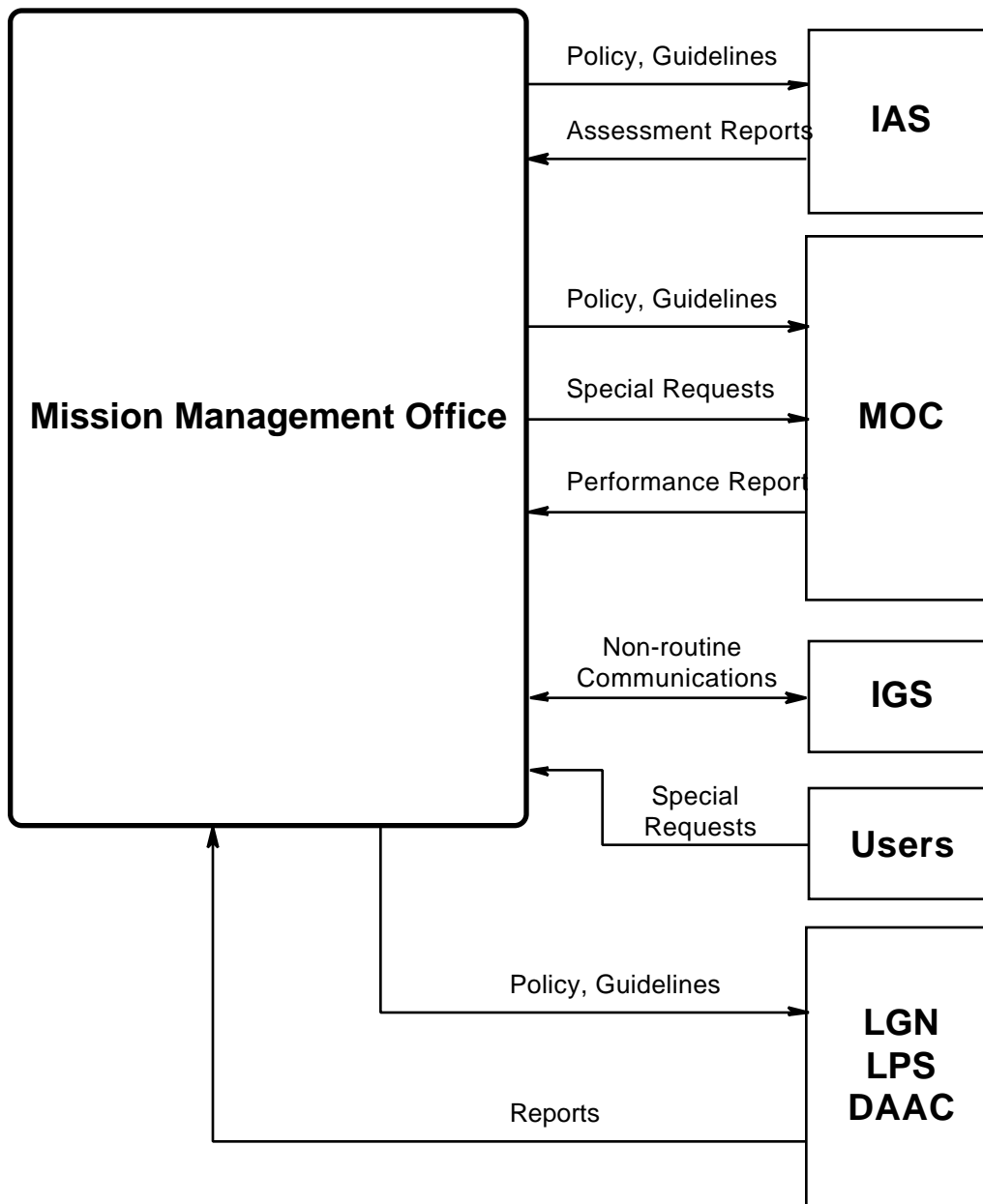
Figure 3.2-11. Mission Management Office Interfaces and Dataflows

3.2.3.2   *Mission Operations Center*

The MOC is the heart of the Ground System for mission planning, S/C operations, and data acquisition. The function of the MOC is to perform mission planning, schedule data acquisitions, conduct S/C operations, and coordinate the activities of all of the ground elements involved in these activities. The MOC interfaces and data flows are shown in Figure 3.2-12.

The MOC performs mission planning activities for future S/C operations. The MOC determines required data collection activities, based on past data collection quality, cloud cover assessment, the Long Term Plan, special requests, and S/C status. It then requests network support from NCC and WOTIS. If support is not available an alternate plan is developed. The MOC forwards orbital elements, generated by the FDF workstations in the MOC, and other pass support data to the NCC, WOTIS and the IGSs required to support the scheduled passes.

Immediately prior to planned operations the MOC establishes voice and electronic message communications with each ground element which is to be involved in the contact and data collection to confirm that all elements are on line and ready. Once contact has been established with the S/C the MOC forwards the command and data packets to the ground station for transmission to the S/C. The Flight Operations Team (FOT) evaluates the telemetry data being received from the ground station in real-time to determine the health and safety of the S/C, and to confirm that the pass activities are being executed as planned. After the contact is terminated the MOC receives status messages from the other ground elements confirming pass activity completion.

The MOC to Landsat 7 Satellite interface is defined in the Space Segment to Mission Operations Center ICD, 23007627A.

The MOC to NCC interface is defined in the Interface Control Document Between the Network Control Center Data System and Mission Operation Centers, 530-ICD-NCCDS/MOC.

The MOC to FDF interface is defined in the Landsat 7 to Flight Dynamics Facility Interface Control Document, 430-11-06-006-0.

The MOC to WOTIS interface is defined in TBD.
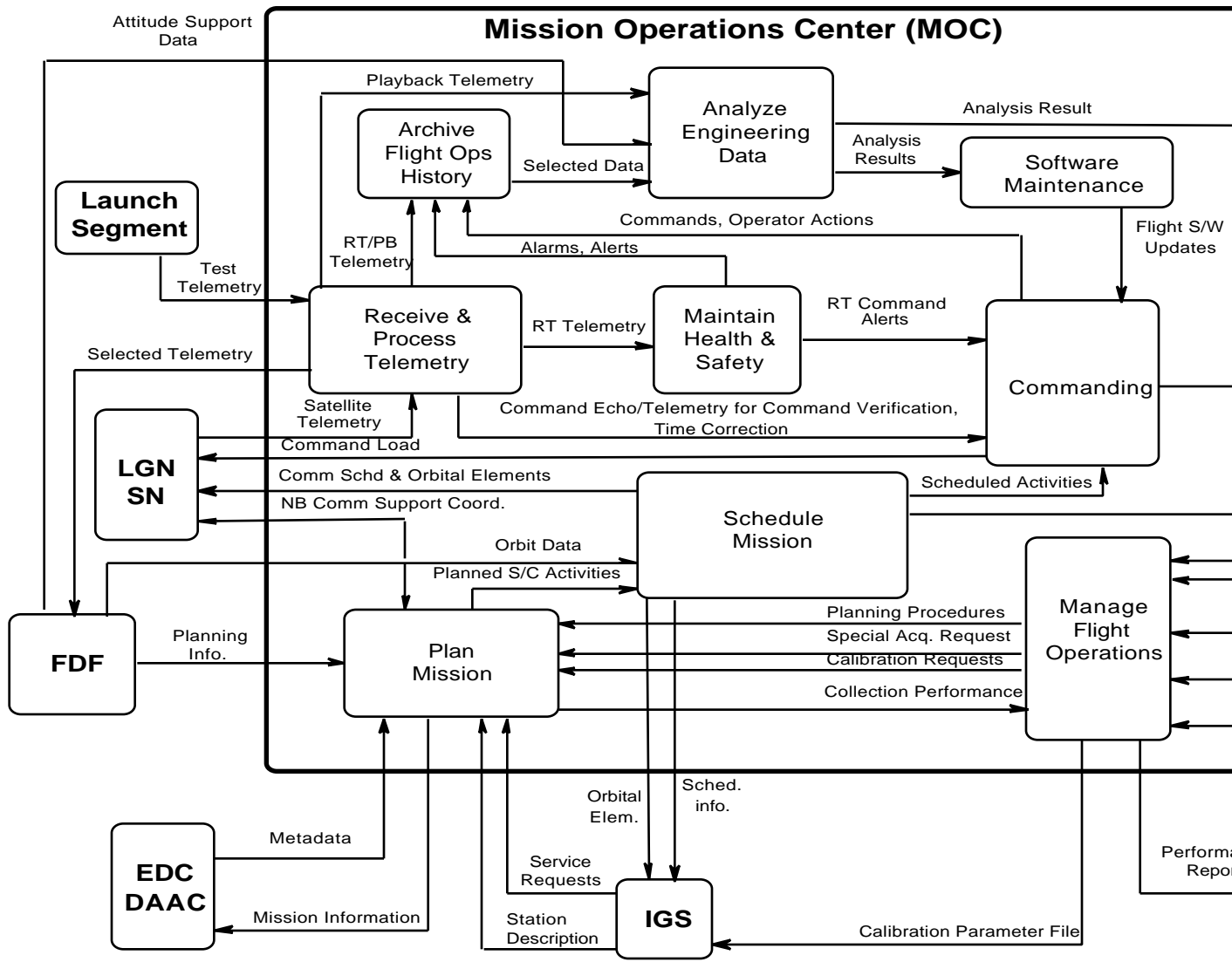
Figure 3.2-12. Mission Operations Center Interfaces and Dataflows

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3.2.3.3 *Network Control Center*

The NCC is a NASA institutional support facility which schedules and coordinates support from the NASA SN for normal Landsat 7 operations. The interface between the NCC and the MOC is defined in the Interface Control Document Between the Network Control Center Data System and Mission Operation Centers, 530-ICD-NCCDS/MOC. The NCC interfaces and data flows are shown in Figure 3.2-13.

The NCC receives requests from the MOC, on a weekly basis, for support from the elements of the SN for the acquisition of tracking data. The NCC coordinates the Landsat 7 requirements with other project requirements, and transmits a support schedule to the MOC. All communication with the NCC is by electronic message transfer for normal operations.

In the event of an emergency, NCC will request support from the SN and coordinate the support during the emergency operations. In an emergency, communication with the MOC may be by voice contact. The interfaces between the NCC and the SN are documented in institutional ICDs.

Figure 3.2-13. Network Control Center Interfaces and Dataflows

3.2.3.4   *Wallops Orbital Tracking Information System*
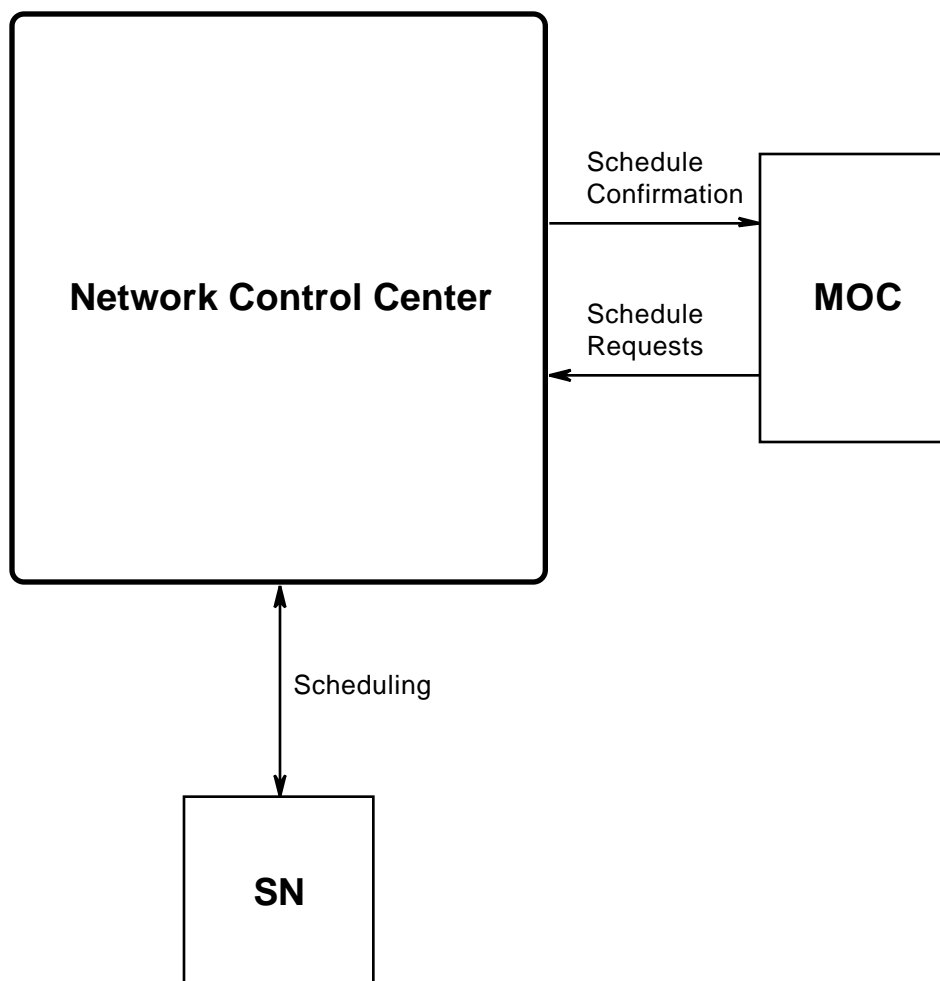
The Wallops Orbital Tracking Information System (WOTIS) is a NASA institutional support facility at Wallops Island, VA which will provide support for the Landsat 7 Project. The function of the WOTIS is to manage the Landsat Ground Network Stations support of Landsat 7. The interfaces and data flows for the WOTIS are shown in Figure 3.2-14.

The WOTIS receives requests from the MOC on a weekly basis for support by the LGN Stations for command transmission, telemetry data acquisition, Wideband data acquisition, and tracking support. The WOTIS coordinates these support requests with other satellite support requirements, and generates a support schedule which is transmitted to the MOC. The LGN stations receive the pass support information from the MOC via the WOTIS.

Immediately prior to planned operations involving the LGN stations, the MOC establishes voice and/or electronic message communications with each ground element involved in the contact and the resulting data collection, to confirm that all elements are on line and ready. Once contact has been established with the S/C the MOC sends the command and data packets to the S/C via the active LGN station, and the station sends the telemetry data to the MOC for real-time evaluation by the FOT. After the contact is terminated the WOTIS receives status messages from the LGN station confirming pass activity completion, and transmits the information to the MOC.

The interface between the MOC and the WOTIS is defined in TBD ICD.

TBS

Figure 3.2-14. WOTIS Interfaces and Dataflows

3.2.3.5 *Flight Dynamics Facility*

The Flight Dynamics Facility (FDF) is an institutional support element of GSFC which will support all phases of the Landsat 7 mission; this includes Pre-launch, Launch and Ascent, Early Orbit, Activation and Checkout, Routine Operations, and Special Operations. The FDF provides the following services for the Landsat 7 Project: trajectory analysis, launch window analysis, orbit maneuver planning and evaluation, planning and scheduling aids, attitude and orbit support, local oscillator frequency determination, and station acquisition data support.

The FDF interfaces and data flows are shown in Figure 3.2-15. Many FDF functions are performed by FDF-provided software that is resident on an FDF workstation in the MOC. The software is run by the MOC's Flight Operations Team (FOT). For ease of understanding, all FDF functions are shown in the FDF in Figure 3.2-15. In fact, all of these capabilities are still present in the FDF, and are available in case of need.

The FDF interfaces with the Landsat 7 elements via electronic network, paper, and human interaction. During the operational phase of the project all FDF interfaces with other Landsat 7 elements are to, or through, the MOC. During development, integration and test there is a direct interface between the MOC and the Lockheed Martin factory at Valley Forge, PA to facilitate Landsat 7 System testing. This link also serves as a means of familiarizing the Flight Operations Team with S/C operation. The FDF interface is defined and controlled in the Landsat 7 to Flight Dynamics Facility Interface Control Document, 430-11-06-006-0.

Pre-launch, the FDF receives the following data:
* Star catalog requirements;
* Sensor models;
* Propulsion System data;
* Satellite operating constraints;
* IGS position data.
and produces the Star Catalog.

After launch, the FDF receives the following data:
* Event schedules;
* ETM+ misalignment data;
* Propulsion and sensor model updates;
* S/C telemetry; and,
* Tracking data,

and generates the following products:
* Predicted orbit state vectors;
* Definitive ephemeris;
* Attitude offset parameters;
* Star Catalog updates;
* Orbit maneuver command data; and,
* Numerous planning aids and miscellaneous products.

For a detailed list and description of FDF services and products refer to the Landsat 7 to Flight Dynamics Facility Interface Control Document, 430-11-06-006.
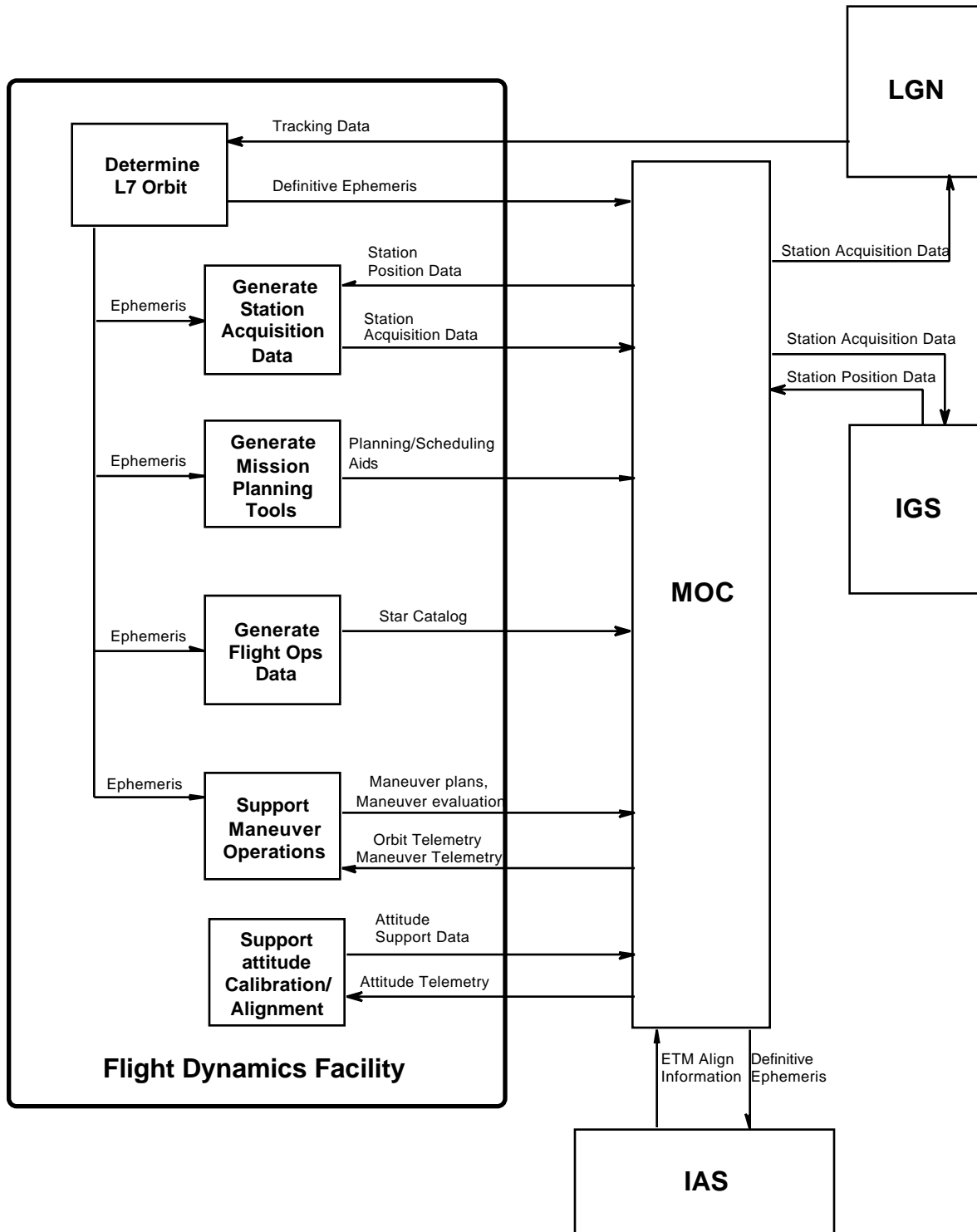
Figure 3.2-15. Flight Dynamics Facility Interfaces and Dataflows

3.2.3.6   *Landsat 7 Processing System*

The Landsat 7 Processing System is the Wideband data processing facility for the Landsat 7 Project. It is located at the EROS Data Center (EDC) in Sioux Falls, SD. The function of the LPS is to receive and record up to four 75 Mbps Wideband data streams from the LGS, process the data to Level 0R format, generate the associated Browse and Metadata files, and transfer the files to the EDC DAAC. The LPS wil process up to an average of 250 scenes per day to Level 0. The interfaces and data flows for the LPS are shown in Figure 3.2-16.

The LPS receives raw data from the LGS and records the data on disks. The data consists of two or four 75 Mbit/s streams of real time or playback Wideband data. The LPS performs CCSDS and BCH error detection and correction processing on the data and generates link quality data files. The LPS then processes the Wideband data Major Frames, de-interleaving the bands, reversing and aligning scans. The Payload Correction Data is extracted, and PCD files and accounting information are produced. LPS determines WRS scene boundaries, and generates Band, Browse and Metadata files. The data is sent to the EDC DAAC, and accounting data for anomaly processing is sent to the MOC.

The interface between the LGS and the LPS is defined in the Interface Control Document Between the Landsat 7 Ground Station and the Landsat 7 Processing System, 560-1ICD/0794. The Landsat 7 S/C to Landsat Processing System interface is defined in the Data Format Control Book (DFCB) Vol. IV - Wideband Data, 23007702-IVC. The interface between the LPS and the EDC DAAC is defined in the Earth Observing System (EOS) Data and Information System (DIS) Core System (ECS) to Landsat 7 Interface Control Document, TBD. The interface between the LPS and the IAS is defined in the Landsat 7 Processing System to Image Analysis System Interface Control Document, TBD.

3.2.3.7   *EDC Distributed Active Archive Center*

The EDC DAAC is located at the EDC in Sioux Falls, SD. The function of the EDC DAAC for Landsat 7 is to archive the LPS-produced data files and provide image data products to the user community. The interfaces and data flows for the EDC DAAC which apply to Landsat 7 are shown in Figure 3.2-17.

The EDC DAAC receives the Level 0R processed data, Browse Data and Metadata from the LPS and places it in the archives. The interface between the EDC DAAC and the LPS is defined in the Earth Observing System (EOS) Data and Information System (DIS) Core System (ECS) to Landsat 7 Interface Control Document, ICD TBD.

The EDC DAAC also receives Browse Data and Metadata, but not image data products, from the IGSs for the image data in their archives. The interfaces between the EDC DAAC and the IGSs is defined in the Landsat 7 to International Ground Stations Interface Control Document, 23007640.

The EDC DAAC provides requested Level 0R products to the IAS for image quality assessment, and receives the Calibration Parameter File from the IAS. The interface between the EDC DAAC and the IAS is defined in the Earth Observing System (EOS) Data and Information System (DIS) Core System (ECS) to Landsat 7 Interface Control Document, TBD.

The EDC DAAC provides Metadata to the MOC for use in assessing scene satisfaction. The interface between the DAAC and the MOC is defined in the Earth Observing System (EOS) Data and Information System (DIS) Core System (ECS) to Landsat 7 Interface Control Document, TBD
.

The EDC DAAC receives orders from users for products, supplies those products and billing information to the Users. The interface between the Users and the EDC DAAC is defined in the ECS Users Guide.
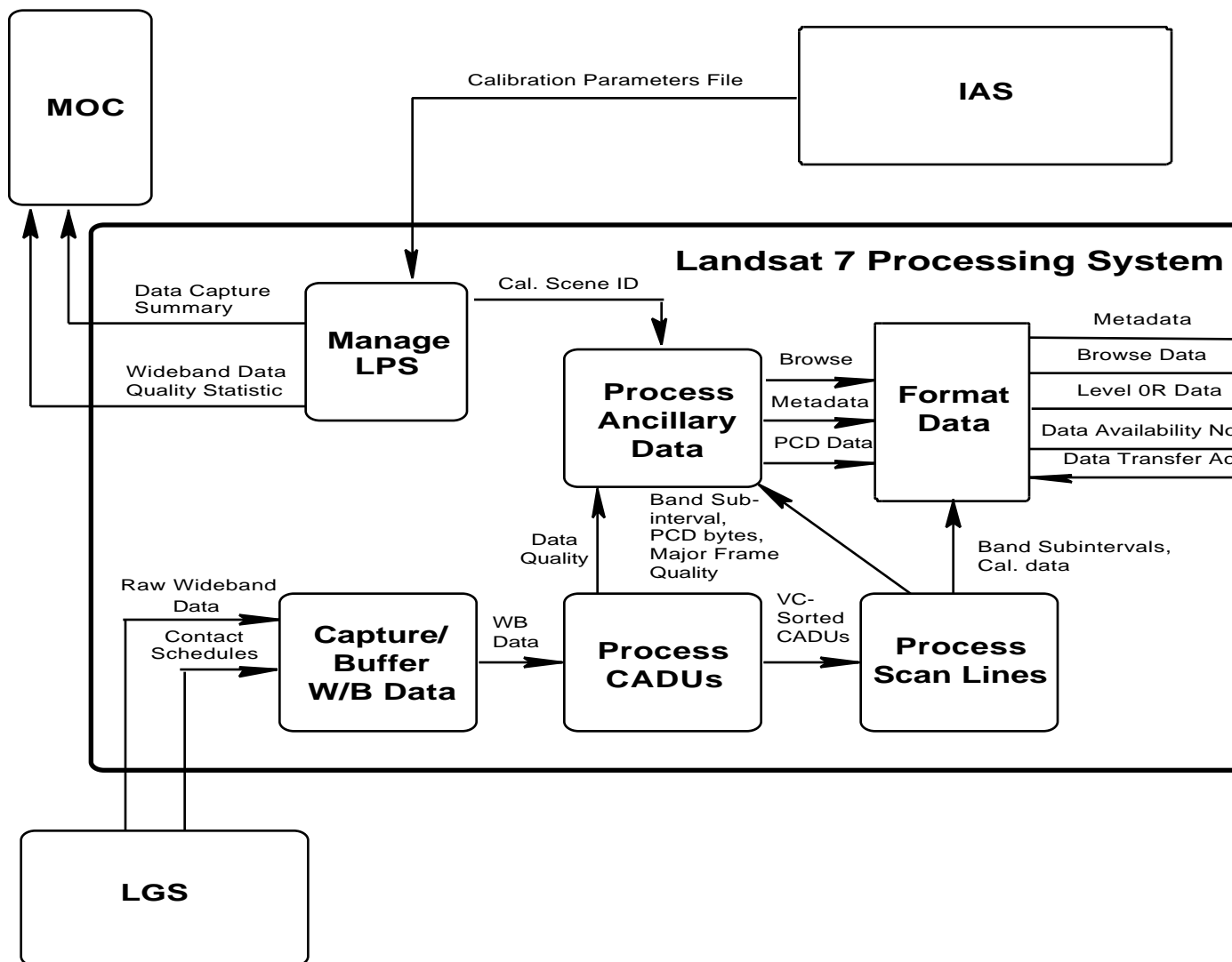
Figure 3.2-16. Landsat 7 Processing System Interfaces and Dataflows

EDC Distributed Active Archive Center

Search Dialog

Product Order

Coordination

Search & Access

Account Coord.

Retrieve Archive info.

Level 0R Data Products

Fulfill Product Orders

Status Dialog

User

Retrieve Data Product

Order Status

IGSs

Browse Data

Metadata

Archive Data

Perform Billing & Accounting

Billing Dialog

Registration Dialog

Provide User Services

Metadata/Browse

Level 0R Data

IAS

LPS

Metadata

Browse

Level 0R

Data Availability Notice

Data Transfer Acknowledge

Calibration Parameters File
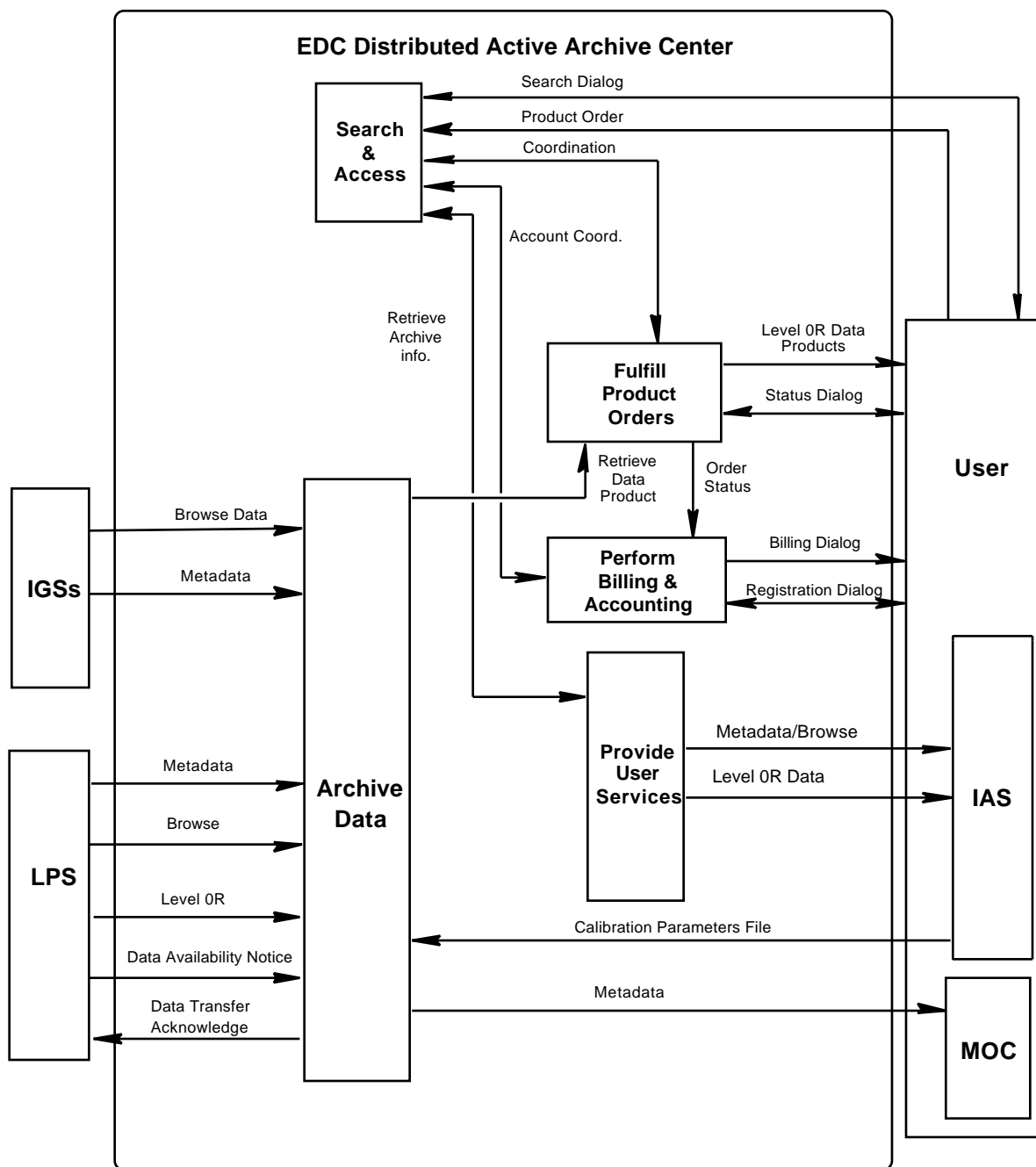
Metadata

MOC

Figure 3.2-17. EDC Data Active Archive Center Interfaces and Dataflows

3.2.3.8 *Image Assessment System*

The Image Assessment System (IAS) is an element of the Landsat 7 Ground System, and is located in Sioux Falls, SD at the Earth Resources Observation System (EROS) Data Center (EDC). The IAS is responsible for image assessment, instrument calibration, and data quality checks of a sparse sample of scenes. It calculates ETM+ misalignment data and generates calibration parameters. The IAS interfaces and data flows are shown in Figure 3.2-18.

The IAS interfaces with the MMO, MOC, LPS, and EDC DAAC. The IAS receives certain data from sources which are not Landsat 7 Project elements. These data include the following: pre-launch characterization of the ETM+, Ground Control Point location and elevation, solar radiance and spectral data, and ground truth data.

The IAS receives Project direction and guidance from the MMO and provides Wideband data assessment reports to the MMO. The IAS to MMO interface is defined in Section 4 of the Mission Operations Plan, TBD.

The IAS receives performance and trend data from the MOC, and definitive ephemeris data from the FDF via the MOC. It provides assessment reports, calibration parameters files, calibration requests, and ETM+ alignment data (TBR) for the FDF to the MOC. The IAS to MOC interface is defined in the Image Assessment System to Mission Operations Center Interface Control Document, TBD.

The IAS receives reprocessing request dispositions from the LPS and sends calibration parameters files, and reprocessing requests to the LPS. The IAS to LPS interface is defined in the Landsat 7 Processing System to Image Assessment System Interface Control Document, TBD.

The IAS receives Level 0R products from the LP DAAC, and supplies product orders and calibration parameters files to the EDC DAAC. The IAS to EDC DAAC interface is defined in the Earth Observing System (EOS) Data and Information System (DIS) Core System (ECS) to Landsat 7 Interface Control Document, TBD.
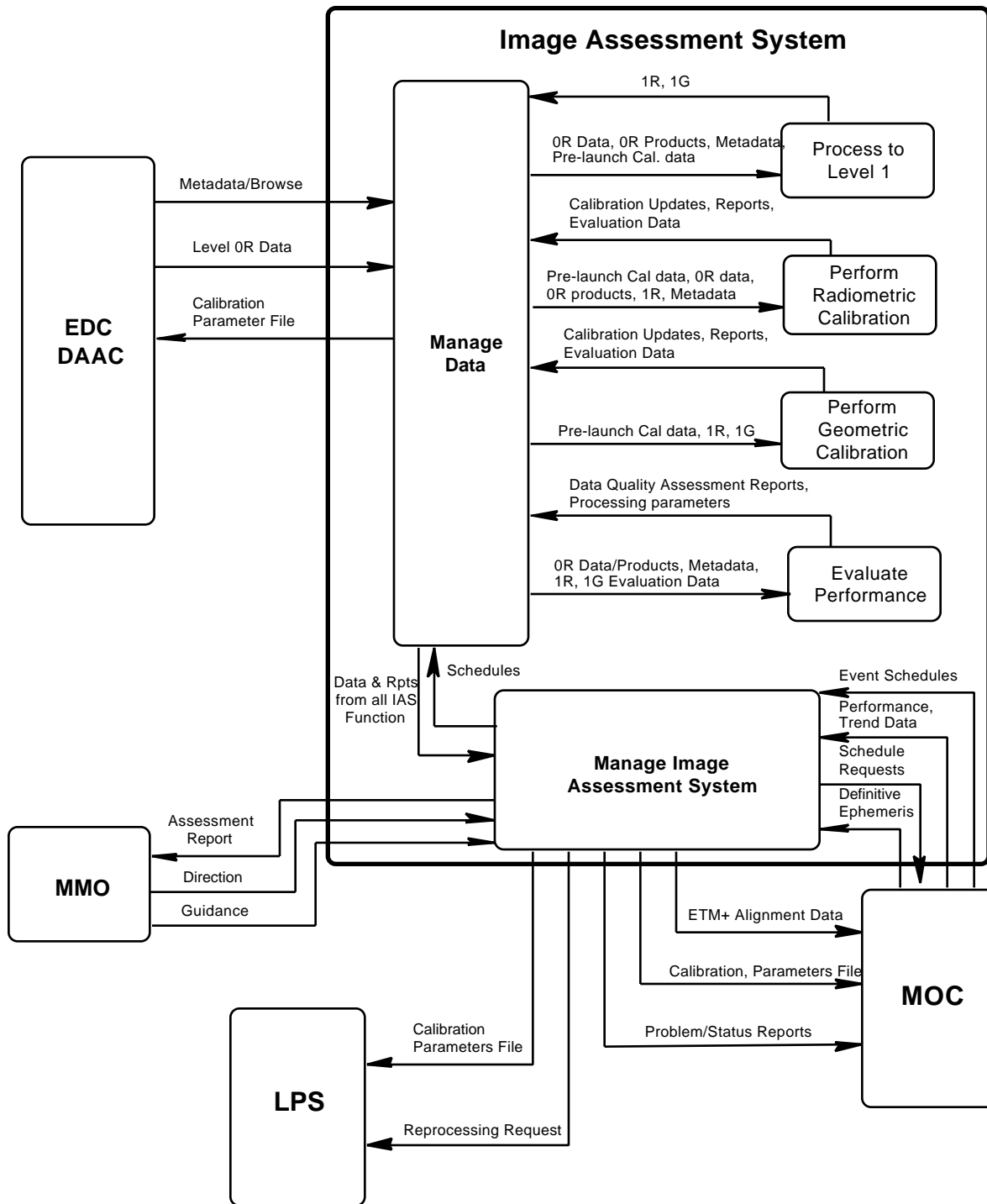
Figure 3.2-18. Image Assessment System Interfaces and Dataflows

3.3   *Data Flows*

This section traces the flow of the various data types from their origin to their destination(s), and describes the transmission medium and data forms along the way. By tying together, at the interfaces, the elements that handle the data in an end-to-end flow, it provides a clearer understanding of the acquisition and use of the data. Figure 3.3-1 shows an overall end-to end data flow for Landsat 7 operations. The individual data types will be traced in the following sections.

3.3.1   Telemetry Data Flow

The Telemetry Data flow through the Landsat 7 System is shown in Figure 3.3-1. Telemetry is generated continuously on the S/C as described in Section 3.2.1.1.1. All telemetry is stored by the Solid State Recorder (SSR). If the S/C is in contact with an LGN station or the SN, the telemetry will also be transmitted to the ground in real-time. The 1.216 or 4.864 Kbps real-time baseband data is PSK modulated on a 1.024 Mhz subcarrier, and then the real-time data and/or the 256 Kbps playback data PM modulates a 2287.5 Mhz carrier for transmission to the ground. The receiver on the ground demodulates the data and sends it to a bit synchronizer where the data is regenerated as NRZ-L data and a clock signal is generated. At this point the data is still in CCSDS packets. It is then formatted into TCP/IP packets for transmission across the Nascom links to the MOC. In the MOC the TCP/IP and CCSDS data is stripped and the data is stored for archival purposes as well as being processed in real time for display and evaluation.

3.3.2   Command Data Flow

The Command Data flow through the Landsat 7 System is shown in Figure 3.3-1. The command data is assembled into CCSDS packets, encoded, formatted for TCP/IP by the MOC, and presented to Nascom as NRZ-M serial digital data for transmission to the LGN or SN. At the station the TCP/IP data is stripped, and the packetized data PSK modulates a 16 Khz subcarrier, which in turn PM modulates a 2106.4 Mhz carrier. This signal is received and demodulated by the S-band transponder on the spacecraft. The NRZ-M baseband signal is recovered from the subcarrier demodulator, and decoded to produce a NRZ-L data stream. This data is then processed to remove the CCSDS data, and the original command data is then sent to the S/C Controls Interface Unit (CIU).

3.3.3   Tracking Data Flow

The Tracking Data flow is shown in Figure 3.3-1. The FDF provides guidelines for the scheduling of tracking data acquisition to the MOC. The MOC uses these guidelines to schedule sufficient tracking passes using the SN or the LGN. During the tracking passes an S-band carrier modulated with a pseudo-random noise (PN) code is transmitted to the S/C. The S-band Transponder on the S/C retransmits the PN code on a coherent carrier with a frequency relationship to the received carrier equal to 240/221. Upon receipt at the ground station the tracking data is forwarded to the MOC in IP encapsulated 4800-bit blocks. The MOC strips the IP header and makes the tracking data available for processing on the FDF workstation in the MOC. Using the Tracking Data, the FDF performs orbit determination, generates a definitive solution vector, and propagates a predicted ephemeris. The definitive orbit data is provided to the IAS. The predicted ephemeris is used in the generation of planning and scheduling aids, and to generate uplink files for use by the FSW. The MOC also schedules passes for non-coherent tracking (one-way Doppler); the resulting data is sent from the station to the FDF for use in determining the S-band oscillator frequency drift. The drift data is sent to the MOC in the form of a Local Oscillator Frequency Report.

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The FDF monitors the quality of the tracking data and notifies the MOC of any adjustments required in the scheduling of tracking passes, such as more frequency or greater separation through the orbit or day. Time delay measurements made by the ground station during tracking passes are forwarded to the MOC in the form of operational messages. The MOC uses these to calculate the drift of the S/C clock and generate clock updates that are uplinked to the S/C as required to correct the clock.

The FDF also advises the MOC when orbit adjustment is required, and provides maneuver data files to the MOC upon request. The MOC converts the data files to command files, and transmits them to the Landsat 7 S/C via the LGN or SN.

3.3.4 Wideband Data Flow

The Wideband Data flow is shown in Figure 3.3-1. The Wideband Data is acquired and stored and/or transmitted to selected ground stations according to a pre-planned schedule which is carried out autonomously via onboard stored commands. The S/C starts transmitting real-time data and/or playback data at the scheduled time to the selected ground stations when the proper commands stored in the SCP memory are executed. The ground stations must be ready to acquire data as they are transmitted.

If the LGS receives the Wideband Data, it demodulates the data, bit syncs the data, and passes the data directly to the LPS in real-time, where it is captured on disk. If the Wideband Data is received by a LGN ground station other than the LGS, the data is demodulated and stored onto tapes which are transmitted to the LGS by common carrier. The LGS reads the tapes and transmits the raw data to the LPS.
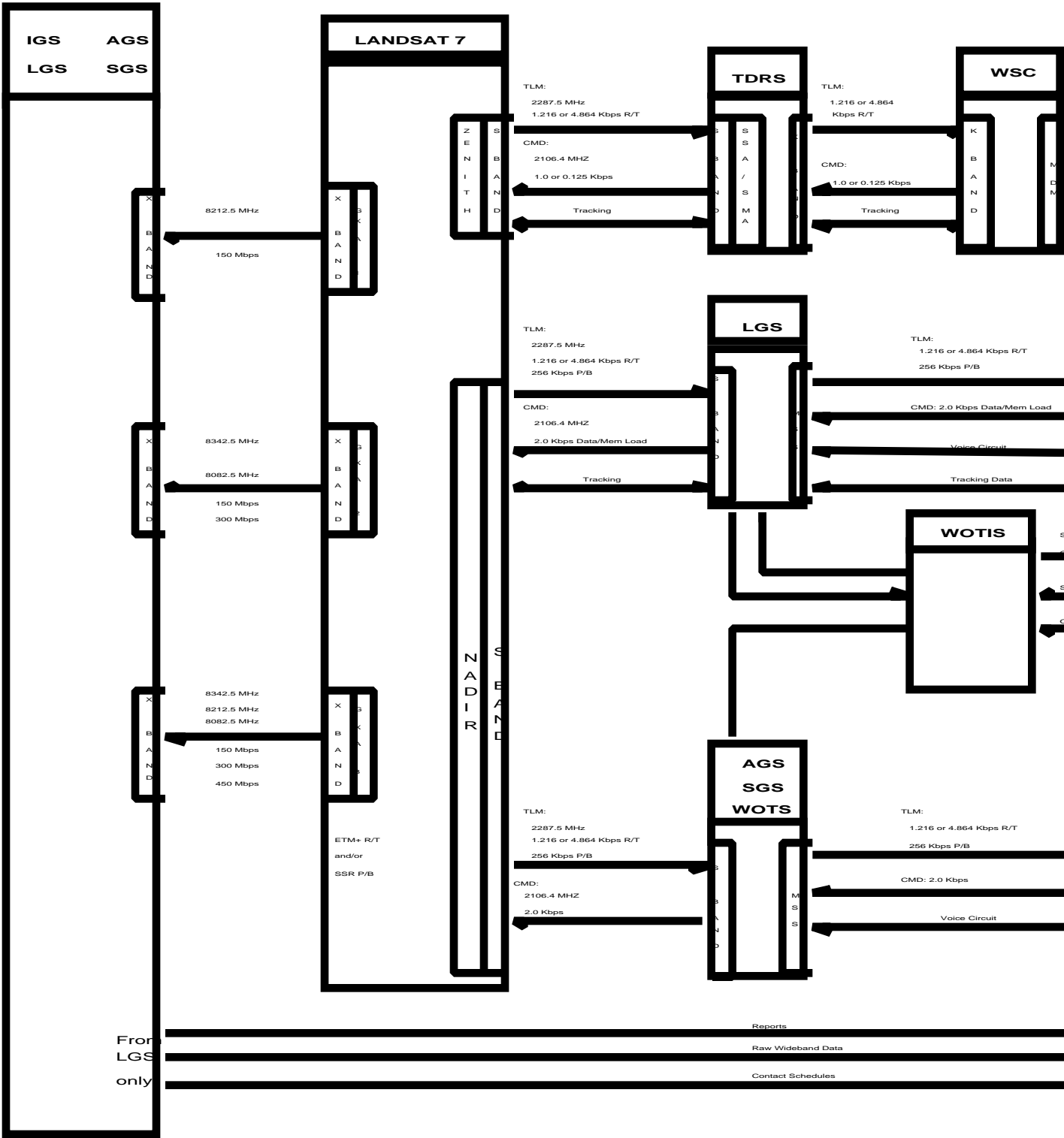
The LPS stores the raw data on tape for 30 days, in case any reprocessing is needed. The LPS processes the raw data into the Level OR data product; at the same time it generates a browseable image, and attaches metadata generated during the processing of the data. The data is placed in a temporary file, and the EDC DAAC is notified that the data is available. The EDC DAAC retrieves the data from the LPS and informs the LPS when it has successfully archived the data. Image data products may be ordered by any user.

If the Wideband Data is received by an IGS, the IGS processes and archives the data and sends metadata and browse files to the EDC DAAC.

3.3.5 Planning and Operations Message Data Flow

The planning and operations messages are either sent or received by every one of the ground elements shown in Figure 3.3-1. The MMO sets the ground rules for data acquisition, and sends any special requests to the MOC. The MOC generates a data acquisition plan and sends support requests to the NCC and the WOTIS. The NCC and WOTIS send support schedules to the MOC. The MOC receives pass support data and predicted ephemeris data from the FDF and sends event schedules to the FDF. The MOC sends support schedules and pass support data to the IGS stations and the WOTIS. The WOTIS sends pass support data and support schedules to the LGN stations. The LGS sends pass support schedules to the LPS. There is voice coordination among the NCC, MOC, LGN, and LPS during the pass. The LGN stations send contact reports and equipment status reports to the MOC and tracking data to the FDF and the FDF Work Stations in the MOC.

The LPS sends data availability notices to the EDC DAAC, and the EDC DAAC sends data transfer acknowledgment messages to the LPS. The EDC DAAC receives product orders from the Users and exchanges status and billing messages to the users. The IAS sends data product requests to the EDC DAAC and calibration acquisition requests to the MOC. The IAS also sends calibration parameter files to both the LPS and the MOC, problem reports to the MOC and assessment reports to the MMO.

IGS   AGS

LGS   SGS

LANDSAT 7

TDRS

WSC

Z E N I T H

S S B A N D

X B A N D

8212.5 MHz

150 Mbps

X B A N D

S S A / S S M A

K B A N D

M D M

TLM:

2287.5 MHz

1.216 or 4.864 Kbps R/T

CMD:

2106.4 MHZ

1.0 or 0.125 Kbps

Tracking

TLM:

1.216 or 4.864 Kbps R/T

CMD:

1.0 or 0.125 Kbps

Tracking

LGS

X B A N D

8342.5 MHz

8082.5 MHz

150 Mbps

300 Mbps

X B A N D 2

S B A N D

TLM:

2287.5 MHz

1.216 or 4.864 Kbps R/T

256 Kbps P/B

CMD:

2106.4 MHZ

2.0 Kbps Data/Mem Load

Tracking

TLM:

1.216 or 4.864 Kbps R/T

256 Kbps P/B

CMD: 2.0 Kbps Data/Mem Load

Voice Circuit

Tracking Data

WOTIS

N A D I R

S B A N D

X B A N D

8342.5 MHz

8212.5 MHz

8082.5 MHz

150 Mbps

300 Mbps

450 Mbps

X B A N D 3

S B A N D

ETM+ R/T

and/or

SSR P/B

AGS

SGS

WOTS

S B A N D

M S S

TLM:

2287.5 MHz

1.216 or 4.864 Kbps R/T

256 Kbps P/B

CMD:

2106.4 MHZ

2.0 Kbps

TLM:

1.216 or 4.864 Kbps R/T

256 Kbps P/B

CMD: 2.0 Kbps

Voice Circuit

From
LGS
only

Reports

Raw Wideband Data

Contact Schedules

3.4   *Data Description*

The Landsat-7 System requirements specify that all data transfers between the S/C and the ground utilize the Consultative Committee for Space Data Systems (CCSDS) telecommand and telemetry recommendations. The CCSDS protocols that will be used on Landsat-7 can be divided into layers that roughly correspond to the following layers of the International Standards Organization (ISO) Open System Interconnect (OSI) reference model.

1. The Application Data Layer which consists of the actual satellite data stored in a defined format.

2. The Data Link Layer which is responsible for processing CCSDS headers and trailers required for end-to-end flow control, error detection and correction, and synchronization.

3. The Physical Channel Layer which is responsible for transmission of the data across a physical medium; in the case of Landsat-7 the medium is either the S-band or X-band RF link.

3.4.1 Telemetry

The following description is a brief summary of a portion of the Data Format Control Book, Volume III - Telemetry, 23007702, which is the defining document for telemetry.

The telemetry communications protocol structure is compliant with a CCSDS Grade 2 Bitstream service as shown in Figure 3.4-1. The protocol that will be used on Landsat-7 can be modeled using three layers, consistent with the CCSDS 101.0, 102.0, and 701.0 recommendations, that roughly correspond to the OSI model.

The Application Data Layer in this case is referred to as the Telemetry Packetization Layer (TPL) and it is responsible for generating telemetry minor and major frames. The satellite (TPL layer) uses minor and major frames to organize telemetry words for transmission to the ground. An example of a minor frame is shown in Figure 3.4-2. The telemetry word is 16 bits in length, may represent analog or digital data, and may be partitioned as two eight-bit components. The first word of every minor frame is the frame synchronization word. The second word of every minor frame is the frame identifier. The first eight bits of the frame identifier specify the minor/major frame mode and the second eight bits specify the minor frame count within the major frame.

The minor frame format consists of 64 telemetry words, or 1024 bits total, and its contents are defined as one of six different formats. They are:

1. Normal Mode - the Normal Mode is the basic mode for nominal on-orbit mission operations and satellite imaging. Figure 3.4.2 describes this minor frame mode.

2. Processor Dump Mode - the Processor Dump Mode is for dumping SCP memory contents; a dump of the 192K SCP memory can be performed using 30 words of dump per minor frame.

3. TDF Dump Mode - the TDF Dump Mode is for dumping TDF random access memory (RAM) contents.

4. Launch/Maneuver (Dwell) Mode - the Launch/Maneuver (Dwell) Mode monitors launch, initial orbit acquisition, and maneuver performance. This mode emphasizes ACS and RCS status measurements. This mode can also be used to investigate or trend anomalous behavior by performing a high sample rate dwell on selected analog measurands.

5. Extended FSW Mode - the Extended FSW Mode provides a Normal Mode format, with FSW telemetry content expanding in lieu of Rolling Dump data.

6. Flex Mode - the Flex Mode is a programmable format that is defined by the ground operators. This mode is used to investigate or trend anomalous satellite behavior or to modify the telemetry report as required to satisfy future mission requirements.

Two types of major frame structures are defined based on the rate at which the frames are transmitted to the ground. The 4K major frame consists of 64 minor frames and a fixed period of 16 seconds. The 1K major frame has 64 minor frames and a fixed period of 64 seconds.

The Data Link Layer corresponds to the Virtual Channel Layer, which consists of three sublayers; the Virtual Channel Link Control (VCLC) sublayer, the Virtual Channel Access (VCA) sublayer, and the Physical Channel Access (PCA) sublayer.

The VCLC is responsible for segmenting the bitstream of telemetry minor frames into a pre-defined Bitstream Protocol Data Unit (BPDU) data zone of 652 bytes. Each BPDU data zone contains five minor frames (640 bytes) and twelve fill bytes. A header is also added to the front of the data zone.

The BPDUs are fed into the VCA sublayer where the appropriate headers and trailers are appended to provide for end-to-end flow control. The result is a Virtual Channel Data Unit (VCDU). The VCDU is encoded using a Reed-Solomon error detection and correction algorithm, thus producing a Coded Virtual Channel Data Unit (CVCDU).

The PCA sublayer then adds a synchronization header to create a Channel Access Data Unit (CADU). Finally, the CADU is modulated onto the S band carrier and transmitted over the physical channel. On the ground, the captured data stream is encapsulated in the TCP/IP protocol and transmitted to the MOC via Nascom.

3.4.2 Command

A detailed description of Landsat 7 commanding is provided in Data Format Control Book, Volume ll - Commands, 23007702, which is the defining document for commands, and is controlled "For Official Use Only".
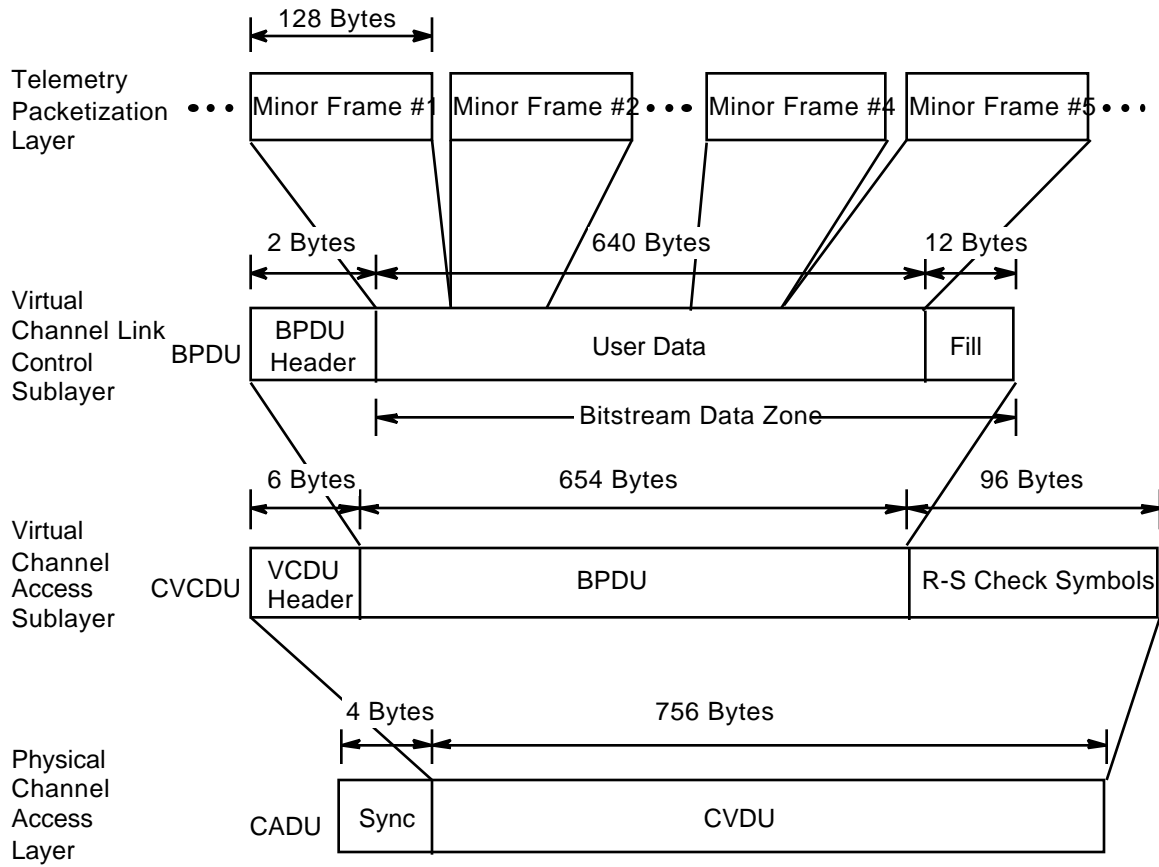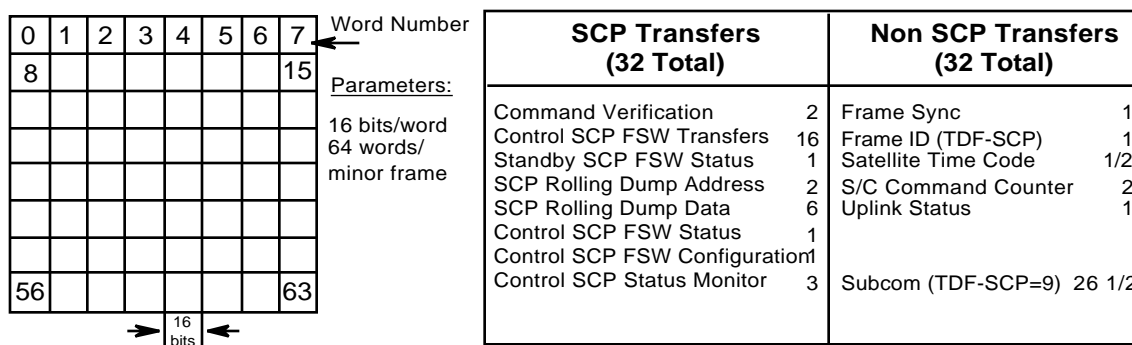
Figure 3.4-1. Telemetry CCSDS Protocol

General Format of Minor Frame

Parameters:

16 bits/word
64 words/
minor frame

SCP Transfers (32 Total)		Non SCP Transfers (32 Total)	
Command Verification	2	Frame Sync	1
Control SCP FSW Transfers	16	Frame ID (TDF-SCP)	1
Standby SCP FSW Status	1	Satellite Time Code	1/2
SCP Rolling Dump Address	2	S/C Command Counter	2
SCP Rolling Dump Data	6	Uplink Status	1
Control SCP FSW Status	1		
Control SCP FSW Configuration	1		
Control SCP Status Monitor	3	Subcom (TDF-SCP=9)	26 1/2

Normal Mode Word Assignments

Figure 3.4-2. Telemetry Data Minor Frame

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3.4.3 Wideband Data

The following description is a brief summary of a portion of the Data Format Control Book, Volume IV - Wideband Data, 23007702, which is the defining document for Wideband data.

The wideband communications protocol structure is compliant with a CCSDS Grade 3 Bitstream service (see Figure 3.4-3). The protocol that is used can be modeled using three layers that roughly correspond to the OSI model.

The Application Data Layer is accomplished by the Enhanced Thematic Mapper Plus (ETM+). It produces a data stream comprised of a continuous succession of Major Frames. Each Major Frame contains the data for one complete forward or reverse scan of the ETM+ scan mirror. See Figure 3.4-3 for a description of a Major Frame.

A Major Frame is partitioned into Minor Frames. The Minor Frame data structure is a specific pattern for organizing groups of ETM+ data words. It is 85 words (8 bits) in length consisting of 16 separate groups of 5 words, 4 data words from Band 6, and 1 spare data word. The Minor Frame data structure is shown in Figure 3.4-4.

Seven separate minor frame formats, or minor frame format groups, are used to accommodate the required ETM+ scan events and scene data. A brief description of six of the minor frame formats can be found in Figure 3.4-3. The seventh group, scene data, is provided in two specified Scene Data formats. Figure 3.4-5 presents the scene pixel pattern for Scene Data Format 1, which includes band 1 through 6, and Figure 3.4-6 presents the scene pixel pattern for Scene Data Format 2, which includes bands 6, 7, and PAN.

The Data Link Layer is referred to as the Virtual Channel Layer and it consists of three sublayers; the Virtual Channel Link Control (VCLC) sublayer, the Virtual Channel Access (VCA) sublayer, and the Physical Channel Access (PCA) sublayer.

The mission data from the ETM+ is delivered to the VCLC sublayer where a Landsat-7 unique data pointer is inserted to provide the end user the ability to accurately reconstruct the data stream. Additionally, a Bose-Chaudhuri-Hocquenghem Error Detection and Correction code is added to achieve the required bit error rate of 10^{-6}.

The data stream is then fed to the VCA sublayer where the appropriate headers and trailers are appended to provide end-to-end flow control. The result is called a Virtual Channel Data Unit (VCDU). The PCA sublayer then adds a synchronization header to create a Channel Access Data Unit (CADU).

Finally, the CADU is modulated and transmitted over the physical channel to a selected site of the LGN or an IGS. If the wideband data is received by a LGN ground station other than the LGS, the data is stored onto tapes which are transmitted to the LGS by common carrier. The data is then transferred from the LGS to the LPS, and consists of pairs of 75 Mbps data streams of bit synchronized, raw data.

The LPS outputs consist of level OR image data products, metadata, and browse image files. The format of these outputs is defined in Data Format Control Book, Volume V, Landsat 7 OR Distribution Product.

CADU (Channel Access Data Unit)
1040 Words

CADU (Channel Acc
1040 Wor

VCDU (Virtual Channel Data Unit)

VCDU Header
8 Words

VCDU Data Zone
1026 Words

Trailer
2

Sync	Ver	SCID	VCID	VCDU Count	SIG	Hdr Err Cnt	Mission Data	PCD/ Status	BCH Code	Data Pntr	Pntr EDAC	CRC	Sync	Ver	SCID	VCID	VCDU Count	SIG	Hdr Err Cntl	Mission Data
4	2			3	1	2	982	10	30	2	2	2								

Major Frame

Post- amble	SLS	Time Code	Scene Data (~6313 Minor Frames)	EOL	SL SD

Time Code
Six Minor Frames

Postamble
Minor Frames
of (00), except
for Band 6 data

Scan Line Start
One Minor Frame.
Repeat a pattern of 5 words
of (255) followed by 5 words
of (00) eight times. Band 6
data is not pre-empted.

End of Line
Two Minor Frames.
40 words of (00) followed by 40 words
of (255), followed by 40 words of (00), followed
by 40 words of (255). The End of Scan preempts
any detector data, begins at Minor Frame
boundaries, but does not replace Band 6 data.

Scan Line Length
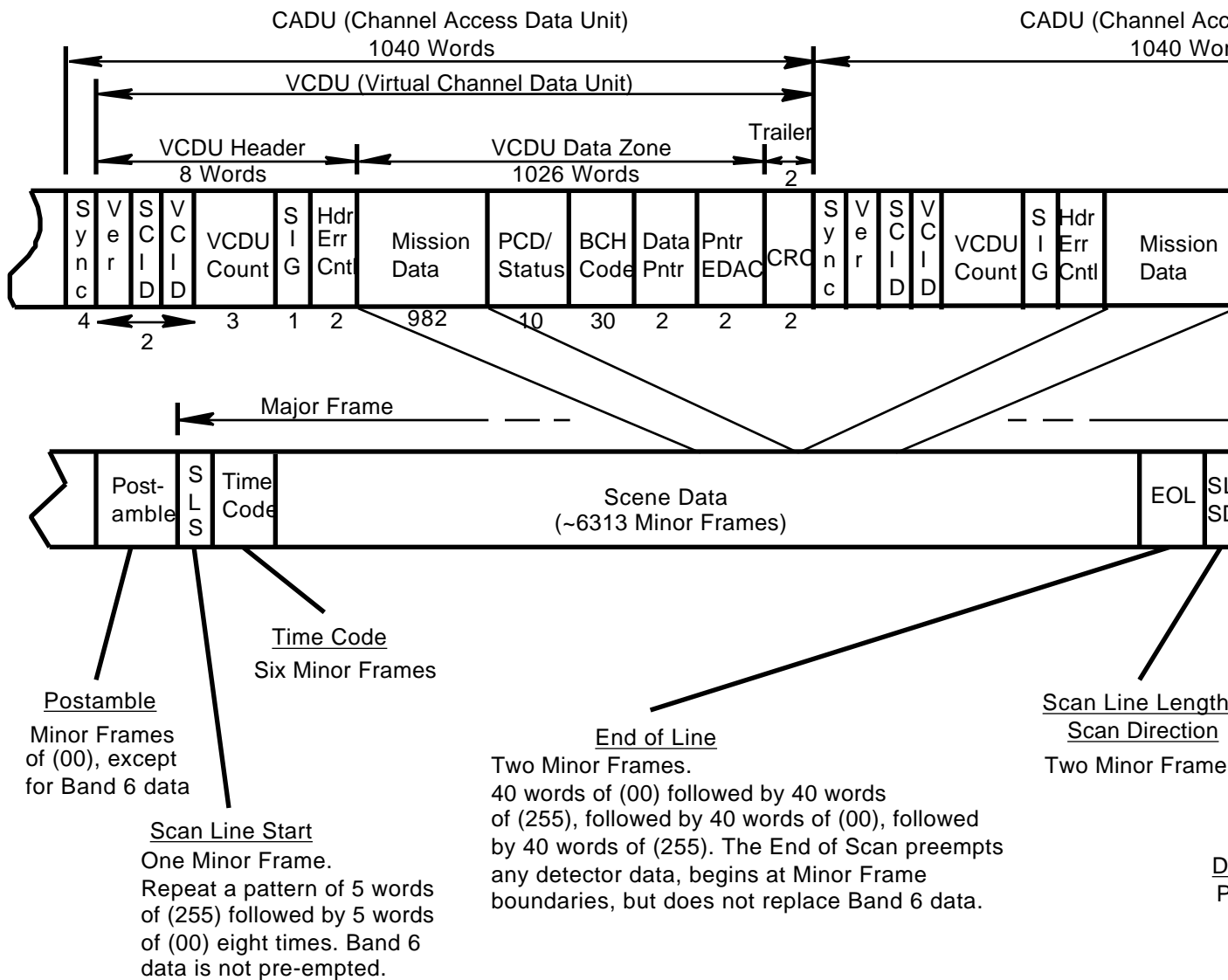Scan Direction
Two Minor Frame

D
P

Figure 3.4-3. Landsat-7 Downlink Data Format

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Error! No topic specified.

Figure 3.4-4. Minor Frame Data Structure

Error! No topic specified.

Figure 3.4-5. Scene Data Format 1

Error! No topic specified.

Figure 3.4-6. Scene Data Format 2

3.4.4 Planning and Operations Messages and Data

Most of the planning and operations messages consist of electronic text or electronic data files which are transmitted across Nascom lines or on Local Area Networks or Ethernets using TCP/IP. A few of the messages utilize paper text or voice contact, and voice can be used in an emergency in place of the paper or electronic text messages. A listing and brief description of the planning and operations messages and data products for each ground element is contained in Table 3.4-1 below.

Product Name	Organization		Description/Purpose	
	From	To		
AN/DN times	FDF	MOC	Time and longitude at which the satellite crosses the equator on ascending and descending passes; used to track WRS scene center times, ground drift	Once/w weeks; burn co
CSA star occultation times	FDF	MOC	Used as reference or diagnostic support	Activati hours o update; once a
Definitive ephemeris	FDF	MOC	Passed through to the IAS for use in geometric performance assessment; not used by the MOC	Once/w WRS at week
Earth sensor sun/ moon interference predictions	FDF	MOC	Used as reference or diagnostic support	Activati hours o update; once a
ETM+ misalignment data	MOC	FDF	Direction cosine matrix specifying ETM+ misalignment with respect to satellite navigation reference frame	When r IAS by
Event schedules	MOC	FDF	Schedule of activities of interest to FDF; includes orbit maneuvers, TDRS passes, telemetry passes, parameter uploads	Once ea
Gimbal angle profiles (X-band)	FDF	MOC	Gimbal angles for the vectors between the satellite and the downlink sites	Once/w weeks; burn co
Ground estimate of true attitude, gyro bias	FDF	MOC	For use as reference or diagnostic support	Real-tin activ'n maneuv routine
IGS position data	MOC	FDF	Station lat., long., elev., and mask characteristics; used for generation of inviews and X-band gimbal angle profiles	Within pre-L; v receipt
Local oscillator frequency report	FDF	MOC	Local oscillator center frequency offset; applied by MOC to arrive at new center frequency which is passed to NCC by MOC for TDRS contacts	Daily L Weekly IOC; M
Orbit maneuver command data	FDF	MOC	Parameters include UTC burn time, burn duration, target attitude, thrusters to be used; these are incorporated by MOC into maneuver commands	Prelimi to man hrs befo
Orbit maneuver planning	FDF, MOC	MOC, FDF	Inputs include offset from reference ground path, descending node drift rate. Outputs are maneuver designs.	Notifica prior to prelimir final 48 maneuv
Post-maneuver evaluation and report	FDF, MOC	MOC, FDF	Analysis of maneuver, includes calibration of thrusters and propulsion system efficiency; outputs are MOC postburn report and FDF postmaneuver evaluation report	MOC p 1 hour o comple postmar w/in 48 comple

Predicted orbit state vectors	FDF	MOC	Predicted state vectors on 12-minute centers; uploaded to satellite	Daily a within 4 comple
Propulsion model data and updates	Factory, MOC	FDF	Engineering data used in maneuver planning and analysis; includes thrust curve, msec/pulse	Prelim. Final: s Updates post-L
Radar ZOE entry/exit times	FDF	MOC	Used by MOC to avoid scheduling communications in areas of degraded RF performance due to a ground radar zone	Once/w weeks; burn co
SAA entry/exit times	FDF	MOC	Times of satellite entry/exit at South Atlantic Anomaly; used by MOC to avoid area of marginal RF communications	Once/w weeks; burn co
Satellite activation coordination	FDF, Factory, MOC	Factory, MOC, FDF	Planning of injection orbit, ground track attainment maneuvers, initialization timelines; outputs are On-Orbit Handbook, On-Orbit Initialization and Checkout Plan	On-Orb Checko prelim.: final: L- Orbit H L-400 d days
Satellite operating constraints	Factory	FDF	Operating constraints for satellite subsystems; includes thermal, commanding, duty cycle, sequencing constraints; published in the On-Orbit Handbook	Prelim. L-180 d
Satellite shadow entry/exit times	FDF	MOC	Times when the satellite enters and leaves either umbra or penumbra	Once/w weeks; burn co

Station inviews	FDF	MOC	AOS and LOS times for stations supporting Landsat 7	Once/w weeks; burn co
Stimulated sensor data	Factory (via MOC)	FDF	ACS sensor data during pre-launch testing at the factory	Real-tir
Sub-satellite point shadow entry/exit times	FDF	MOC	Times when the sub-satellite look point crosses the day/night terminator on the earth	Once/w weeks; burn co
Sun angles at WRS scene centers	FDF	MOC	Angle of the sun with respect to a WRS scene center on the earth	As requ
Sun angles for calibration scheduling	FDF	MOC	Azimuth and elevation of the sun relative to the ETM+ aperture on the satellite; used to schedule FAC and PAC acquisitions	As requ once da 1 day
Sun angles for power monitoring	FDF	MOC	Solar beta angle; used to monitor satellite power subsystem	As requ once da 1 day
TDRS multipath fringe zone entry/exit times	FDF	MOC	Used by MOC to avoid scheduling communications in areas of degraded RF performance due to LS7 and TDRS relative positions	Once/w weeks; burn co
Tracking coverage evaluation report	FDF	MOC	Feedback on tracking data acquisition schedule; used to adjust schedule	Pre-lau mos; Po as requi
Tracking data	FDF	MOC	4800-bit blocks of Landsat 7 and TDRS tracking data	Within receipt

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SECTION 4

4. ACRONYMS AND ABBREVIATIONS

OR	Zero R (level of processing for Wideband Data)
ACS	Attitude Control System
ADA	Angular Displacement Assembly
AGE	Automated Ground Equipment
AGS	Alaska Ground Station
AQPSK	Asynchronous Quadrature Phase Shift Keyed
BCH	Bose-Chaudhuri-Hocquenghem
BPDU	Bitstream Protocol Data Unit
BSU	Baseband Switching Unit
BTC	Bench Test Cooler
C&DH	Command and Data Handling
CADU	Channel Access Data Unit
CCSDS	Consultative Committee for Space Data Systems
CIC	Computer Interrupt Code
CIU	Controls Interface Unit
CLTU	Command Link Transfer Unit
CMD	Command
COMM	Communications Subsystem
CONUS	Continental United States
CTV	Compatibility Test Van
CV	Command Verification
CVCDU	Coded Virtual Channel Data Unit
DAP	Data Acquisition Plan
DAAC	Data Active Archive Center

DFCB	Data Format Control Book
DIS	Data Information System
DLT	Digital Linear Tape
DOC	Department of Commerce
DOI	Department of Interior
ECS	EOS DIS Core System
EDC	EROS Data Center
EOS	Earth Observing System
EPS	Electrical Power Subsystem
EROS	Earth Resources Observation System
ETM+	

LWIR	Long Wavelength Infrared
MMO	Mission Management Office
MOC	Mission Operations Center
NASA	National Aeronautics and Space Administration
Nascom	NASA Communications Network
NCC	Network Control Center
NOAA	National Oceanic and Atmospheric Administration
NRZ-L	Non-Return to Zero Level
NRZ-M	Non-Return to Zero Mark
OSI	Open System Interconnect
PCA	Physical Channel Access
PCD	Payload Correction Data
PDF	Payload Data Formatter
PN	Pseudo Noise
PPF	Payload Processing Facility
PSK	Phase Shift Keyed
PTP	Programmable Telemetry Processor
RAID	Redundant Array of Inexpensive Devices
RAM	Random Access Memory
RF	Radio Frequency
RHC	Right Hand Circular
RTA	Roof Top Antenna
RTC	Remote Telemetry and Command Unit
RTCS	Relative Time Command Sequence
SBRC	Santa Barbara Research Center
S /C	Spacecraft
SCL	Signal Conditioning Unit-Lower Equipment Module

SCP	Standard Controls Processor
SCS	Satellite Checkout Station
SGS	Spitzbergen Ground Station
SMA	S-Band Multiple Access
SN	Space Network
SSA	S-Band Single Access
SSR	Solid State Recorder
SWIR	Short Wavelength Infrared
TBD	To Be Determined
TBR	To Be Resolved
TBS	To Be Supplied
TCP/IP	Transport Control Protocol / Internet Protocol
TDF	Telemetry Data Formatter
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TPL	Telemetry Packetization Layer
TURFTS	TDRS Users RF Test Set
U/P	Uplink Processor
USGS	United States Geological Survey
VAFB	Vandenburg Air Force Base
VCA	Virtual Channel Access
VCDU	Virtual Channel Data Unit
VCLC	Virtual Channel Link Control
VF	Valley Forge
VNIR	Visible and Near Infrared
WB	Wideband
WOTIS	Wallops Orbital Tracking Information System

WOTS   Wallops Orbital Tracking Station

WRS   Worldwide Reference System

WSC   White Sands Complex

WSGT   White Sands (NASA) Ground Terminal

XTX   X Band Transmitter

APPENDIX A
INTEGRATION, TEST AND LAUNCH SUPPORT DATA FLOWS

AO. INTRODUCTION

The Integration and Test (I&T) program includes all system level assembly operations, subsystem, functional and Satellite level performance evaluation tests and environmental tests. Successful completion of I&T will provide confidence that the satellite will perform its assigned mission. The system data flows and inter-segment tests are performed to develop confidence in system interfaces and verify key system requirements. Inter-segment tests will a part of both the I&T and the Launch Support activities. Inter-segment testing will include a 24 hour mission simulation to demonstrate that all segments play together on a time-line that will meet mission requirements. Inter-segment testing is concluded with the successful completion of communications tests on the launch pad, and provides confidence that the entire Landsat 7 System will perform as required at launch. This Appendix describes the additional elements and associated data flows used to verify the interfaces, and compatibility of the elements of the Landsat 7 Ground System with the Landsat 7 S/C. The tests performed during I&T demonstrate the capability of the Landsat 7 System to meet mission requirements, and those performed after shipment to the launch site verify that it is still operating properly at launch.

A1. Integration & Test

The Landsat 7 I&T activities encompasses the Flight Segment I&T, the Ground Segment I&T, and the System I&T. System I&T assumes that both Flight and Ground Segment I&T are essentially complete.

A1.1   Satellite Integration

Integration of the spacecraft will be performed by the satellite contractor, Lockheed Martin Astro Space, at the factory in Valley Forge, PA. Spacecraft integration will be supported by the satellite Automated Ground Equipment (AGE), to include the Satellite Checkout Station (SCS) and RF Test Equipment. The satellite AGE will require integration with Government Furnished Equipment support equipment.

Integration and test of the Enhanced Thematic Mapper Plus (ETM+) will be supported by payload AGE, which will include the Environmental Test Bench, Bench Test Cooler, Thematic Mapper (TM) Calibrator, Spacecraft Simulator Console, Test Data Preprocessor Console, and Data Analysis Workstation.

Integration of the payload with the spacecraft will be the responsibility of the satellite contractor with payload contractor support. After integration of the payload and spacecraft, the integrated satellite will undergo a series of satellite level tests, environmental tests, and alignments.

For more information on Satellite integration, refer to Space Segment Integration & Test Plan, TP 23007560.

A1.2   Ground System Integration

The elements of the Ground Data System and their interfaces with supporting network facilities will be integrated and tested by NASA/GSFC Code 500. The ground system elements which will

be integrated are the Mission Operation Center (MOC), Landsat Ground Station (LGS), Landsat Processing System (LPS), Image Assessment System (IAS), Landsat Ground Network (LGN), and EROS Data Center (EDC) Distributed Active Archive Center (EDC DAAC).

The MOC will be integrated with the LGS, LPS, IAS, EDC DAAC, and IGSs and their interfaces tested. The MOC will also be integrated with support facilities such as, Flight Dynamics Facility (FDF), Network Control Center (NCC), White Sands Complex (WSC), NASA Communications (Nascom), National Meteorological Center, and Landsat Ground Network (LGN).

For a Complete description of ground systems integration, including institutional support facilities, refer to Ground System Integration and Test Plan, document number, 510-21TP/0395.

A1.3 Landsat 7 System Integration Inter-segment Testing

Once the satellite and ground system have each been integrated and tested, the satellite and ground data system will be brought together as a system for inter-segment testing, which will continue through the pre-launch activities. A series of data flows and inter-segment tests will be performed involving the satellite, and its supporting AGE, and elements of the ground system. These system tests and data flows are:

1. ETM+ Data Flows;
2. Command and Telemetry Data Flows;
3. S-band Compatibility Test;
4. Geometric Performance (Jitter) Test;
5. System End-to-End Test;
6. Radiometric Performance Data Flows;
7. Payload Processing Facility (PPF) End-to-End Data Flow; and,
8. Launch Pad Communications Data Flow.

The first six activities will take place at Valley Forge, PA (VF) and are inter-segment tests which bring together the satellite and one or more ground segment elements for testing for the first time (System Integration). The last two will take place at Vandenburg Air Force Base (VAFB) and are either verification that the system is still operating properly after shipment or mating to the rocket, or to verify the necessary configuration and communication links for launch support. Final integration of the satellite and ground system will occur following launch and deployment/checkout, with activation of the X-band downlinks. Figure A1.3-1 is a block diagram showing the elements and data flows for the inter-segment testing while the satellite is at VF. Figure A1.3-2 shows the elements and data flows at VAFB.

A1.3.1 Valley Forge System Integration Tests

A1.3.1.1 ETM+ Data Flows

The ETM+ Data Flows are instrument level data flows which provide early evaluation of ETM+ radiometric, geometric, and spectral performance. The data is also a baseline for comparison to evaluate future performance. Test target and calibration sources include the 100 cm Spherical Integrating Source, the 48 in Spherical Integrating Source (SIS), and the Environmental Test Bench TM Calibrator. The test records raw and formatted Wideband Data from the ETM+ on 8 mm tape using the Payload Automated Ground Equipment and various calibration sources. The data is archived by the IAS and evaluated by the Science Office at GSFC. This is not a true system integration activity, but provides metrics for later testing.

A1.3.1.2 Command and Telemetry Data Flows

The MOC Command and Telemetry Data Flows provides an initial demonstration of the capability of the MOC and FOT to Control the satellite through real time commands, to monitor the health and safety of the satellite, and to verify command receipt and execution via narrowband telemetry.
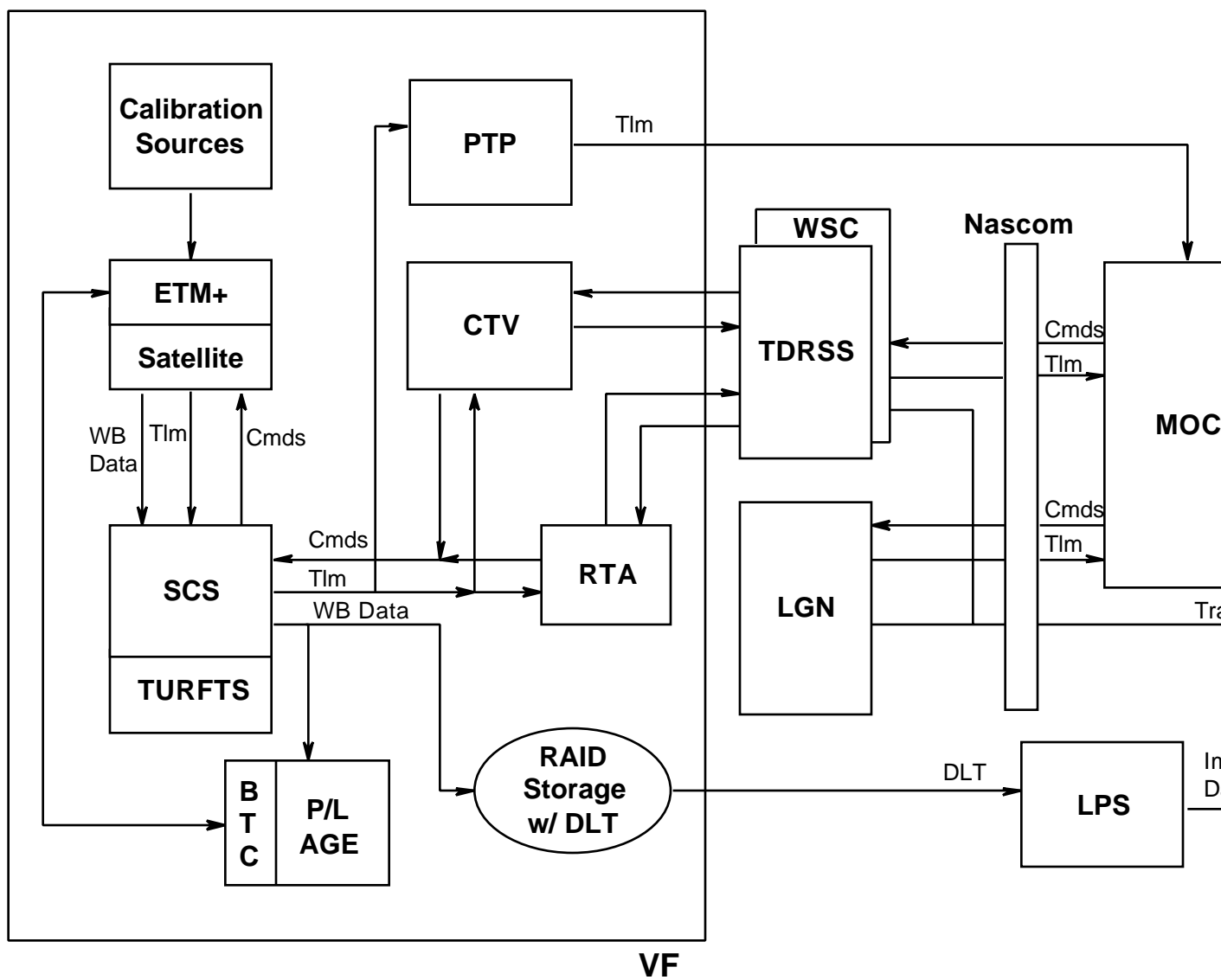
Figure A 1.3-1 Valley Forge Inter-segment Test Configuration

The test configuration includes the Landsat 7 Satellite with its SCS, a Programmable Telemetry Processor (PTP) and modem, and the MOC. The MOC sends properly formatted command packets across a hard-line interface to the satellite, and receives packets of telemetry data. The PTP performs the IP processing at the VF end of the line.

This test verifies the MOC's capability to format and send commands across a hard-line, such as a Nascom line to a ground station, and to receive and process telemetry data. It also validates part of the data base However it does not actually verify any system interfaces.

A1.3.1.3   S-band Compatibility Test

The S-band Compatibility Test provides verification of the satellite RF interfaces with TDRS, LGN ground stations, using the Compatibility Test Van (CTV). In addition it demonstrates compatibility between the satellite and the SN, including the TDRSS and NCC, and the FDF.

The test configuration includes the Landsat 7 Satellite with its SCS, the TDRSS Users RF Test Set (TURFTS), the Roof Top Antenna (RTA) the CTV, TDRSS, the MOC, FDF, and NCC. TDRSS White Sands Complex, the MOC, FDF and NCC will be connected by Nascom as shown in Figure A1.3-1. The MOC will schedule TDRS support with the NCC. The MOC will send commands to the Landsat 7 Satellite via TDRS, the CTV, the RTA, and TURFTS. The Satellite will send Telemetry Data to the MOC via the TURFTS, RTA, CTV, and TDRS. TDRSS will send one-way and two-way tracking data to the FDF for processing. The Satellite will also send Wideband Data on X-band to the CTV via the RTA.

A1.3.1.4   Radiometric Performance Data Flows

The Radiometric Performance Data Flows are used to verify the radiometric performance of the ETM+ payload and the ground processing software, using the 48 inch SIS.

The test configuration includes the Landsat 7 Satellite with its SCS and the ETM+ AGE, the 48 inch SIS, a PTP, a Redundant Array of Inexpensive Devices (RAID) with a Digital Linear Tape (DLT), the MOC, the LPS, the EDC DAAC, the IAS, and the Science Office.

The Landsat 7 Satellite will send Telemetry Data to the MOC via the PTP, and record Wideband Data on the RAID. A tape of the Wideband Data will be generated and sent to the LPS. The LPS will Process the image data and send the Level OR product to the EDC DAAC, the IAS, and the Landsat 7 Science Office. The MOC will process the telemetry and send the data to the Science Office.

A1.3.1.5   Geometric Performance (Jitter) Test

The Geometric Performance Test demonstrates the capability of the system to measure and control the angular displacement at the boresight of the ETM+ instrument. The test demonstrates the capability of the LPS to process the jitter information contained in the PCD data, and for users to correct the data using an approved geometric correction algorithm.

The test configuration is the same as for the Radiometric Performance Data Flows, except that the calibration source used is the Multi-Wedge Collimator.

The data flow is also the same as described in Section A1.3.4

A1.3.1.6 System End-to-End Test

The System End-to-End Test supports the verification of mission critical capabilities and interfaces. The test includes demonstration of the capability of the MOC uplink S/C memory loads and to control satellite imaging and SSR operations. It also includes a 24-hour mission simulation involving the S/C, payload, and mission operations.

The test configuration includes the Landsat 7 Satellite, with its SCS and the ETM+ AGE, the RAID and DLT, a PTP, all Ground System elements, TDRSS, the Alaska Ground Station, and all Nascom links.

This test will exercise all system interfaces and operational capabilities. The test also includes a 24-hour mission simulation using nominal mission day scenarios. The Wideband data will be recorded on the RAID, and a tape provided to the LPS. The FDF will provide planning aids, including ephemeris. The MOC will prepare a daily schedule, schedule pass support, generate command loads, uplink commands, process telemetry, initiate playbacks of Telemetry Data and Wideband Data, and perform post-pass processing. The LPS will process raw Wideband Data to Level OR. The EDC DAAC will obtain data from the LPS and place in the archive. The IAS will perform quality assessment on the data

A1.3.2 Vandenburg Launch Support Tests

The pre-launch phase begins with arrival of the Landsat 7 Satellite at VAFB. The integrated satellite (bus and payload) is initially checked out both visually and electronically in the Payload Processing Facility (PPF) upon arrival for successful transportation from the contractor's facilities. The subsystems are further checked out and prepared for the launch phase. The satellite is subsequently mated to the launch vehicle. After mating and checkout, the pre-launch configuration of the satellite is established by operators using AGE capabilities. During this phase, the MOC may monitor spacecraft operations. The satellite is switched to internal power and is monitored by both the contractor's AGE and the MOC during the launch countdown sequence to continuously confirm launch-ready configuration. The following sections describe pre-launch activities and final preparation for launch. The test configuration is shown in Figure A1.3-2

A1.3.2.1 Payload Processing Facility End-to-End Data Flow

The PPF End-to End Data Flow is used to verify critical system capabilities and interfaces while the satellite is undergoing launch preparation following shipment to the launch site.

The test configuration includes the Landsat 7 Satellite with its SCS, a PTP, the NASA Telemetry Station, a Nascom link, and the MOC.

The MOC will send commands, perform command verification, send memory loads, command memory dumps and verify the dump, and send final stored command loads. Primary link is through the NTS, with the PTP as a backup.

A1.3.2.2 Launch Pad Communications Data Flows

The Launch Pad Communication Data Flow is used to provide a final verification of the system capabilities and interfaces critical to launch, ascent, and early orbit operations.

The test configuration is the same as described in Section A1.3.2.1.

This is mainly a monitoring function to verify that the satellite is in a launch ready state after an initial command and telemetry check. This does include verifying the capability to accept commands periodically.
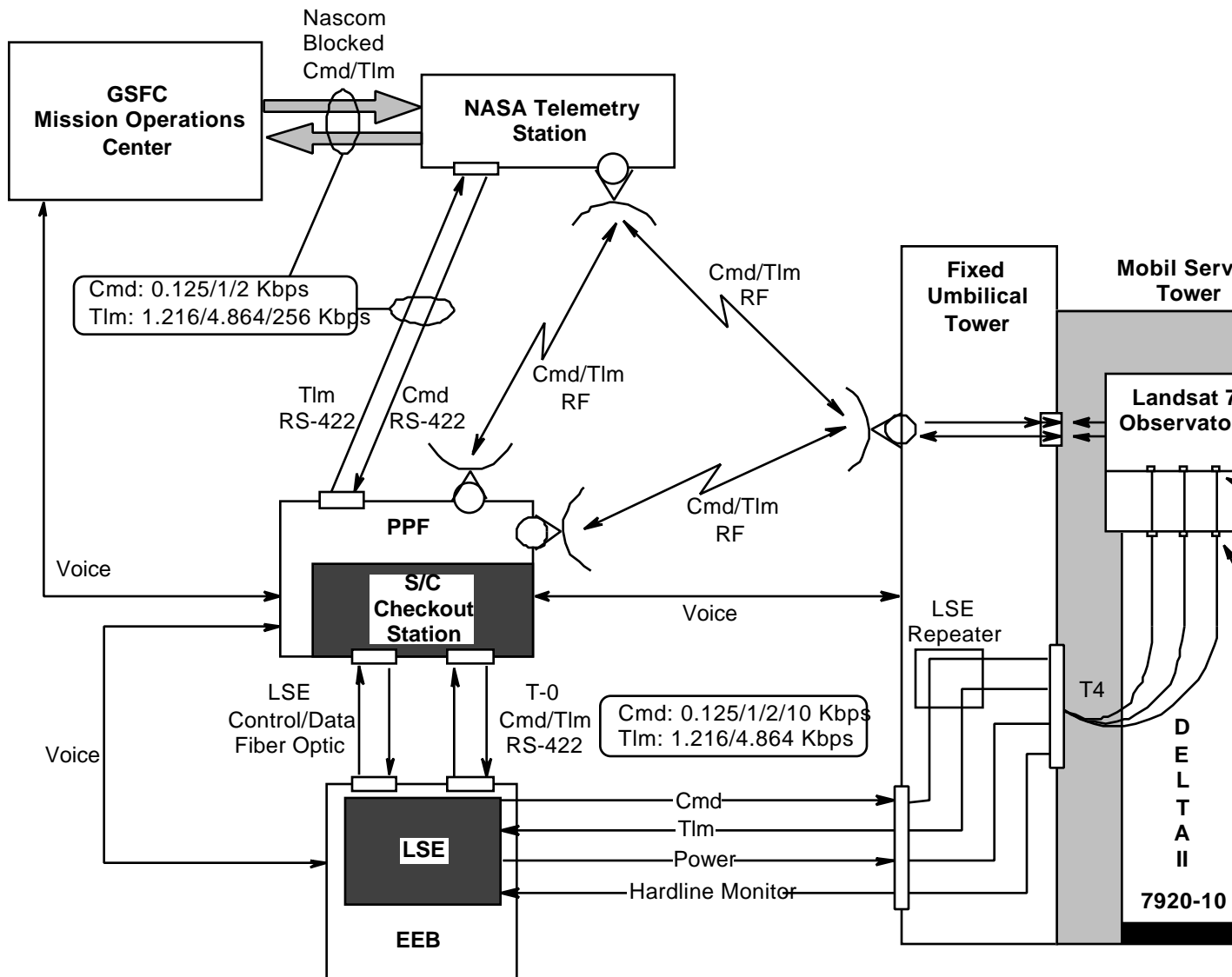
Figure A 1.3-2 Vandenburg Inter-segment Tests Configuration

A1.3.2.3 Launch

The launch phase commences with the termination of the pre-launch phase and includes the launch and ascent, deployment and initialization/activation of the subsystems of the spacecraft and payload for on orbit confidence testing leading to normal operations. Launch and early orbit operations include all autonomous and ground-commanded events from liftoff to starting its mission. This consists of : launch and ascent, early orbit operations, and on-orbit verification and testing. The MOC will monitor the satellite during this time whenever Telemetry Data is available. The system configuration is the same as for contact with a LGN station, except that there will be additional stations available during launch, ascent, and early orbit.